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*NBS Special Publication 305  
Supplement 14*

*Publications of the  
National Bureau of  
Standards  
1982 Catalog*

PUBLICATIONS



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No.305  
SUPPL.14  
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*U.S. Department of Commerce  
National Bureau of Standards*

## NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards<sup>1</sup> was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

**THE NATIONAL MEASUREMENT LABORATORY** provides the national system of physical and chemical and materials measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; conducts materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

Absolute Physical Quantities<sup>2</sup> — Radiation Research — Chemical Physics —  
Analytical Chemistry — Materials Science

**THE NATIONAL ENGINEERING LABORATORY** provides technology and technical services to the public and private sectors to address national needs and to solve national problems; conducts research in engineering and applied science in support of these efforts; builds and maintains competence in the necessary disciplines required to carry out this research and technical service; develops engineering data and measurement capabilities; provides engineering measurement traceability services; develops test methods and proposes engineering standards and code changes; develops and proposes new engineering practices; and develops and improves mechanisms to transfer results of its research to the ultimate user. The Laboratory consists of the following centers:

Applied Mathematics — Electronics and Electrical Engineering<sup>2</sup> — Manufacturing Engineering — Building Technology — Fire Research — Chemical Engineering<sup>2</sup>

**THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY** conducts research and provides scientific and technical services to aid Federal agencies in the selection, acquisition, application, and use of computer technology to improve effectiveness and economy in Government operations in accordance with Public Law 89-306 (40 U.S.C. 759), relevant Executive Orders, and other directives; carries out this mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards guidelines, and managing Federal participation in ADP voluntary standardization activities; provides scientific and technological advisory services and assistance to Federal agencies; and provides the technical foundation for computer-related policies of the Federal Government. The Institute consists of the following centers:

Programming Science and Technology — Computer Systems Engineering.

<sup>1</sup>Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Washington, DC 20234.

<sup>2</sup>Some divisions within the center are located at Boulder, CO 80303.



*NBS Special Publication 305  
Supplement 14*

*Publications of the  
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*Rebecca J. Morehouse, Editor*

*Technical Information and Publications Division  
National Bureau of Standards  
Washington, DC 20234*

*Issued June 1983*

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National Bureau of Standards  
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# CONTENTS

	Page
A Guide to Users of This Publication.....	iv
NBS Publication Program.....	1
1. Introduction.....	1
2. Periodicals.....	1
3. Nonperiodicals.....	1
4. Document Availability and Purchase Procedures.....	2
4.1 NBS Periodical Subscription Rates.....	3
4.2 Prices for Nonperiodicals.....	3
4.3 Former NBS Reference Publications.....	3
4.4 Announcements of NBS Publications.....	5
4.5 Depository Libraries in the United States.....	6
4.6 U.S. Department of Commerce District Offices.....	7
5. Titles and Abstracts of NBS Publications, 1982.....	8
5.1 Journal of Research.....	8
5.2 Journal of Physical and Chemical Reference Data.....	12
5.3 DIMENSIONS/NBS (discontinued October 1981).....	14
5.4 Monographs.....	15
5.5 Handbooks.....	16
5.6 Special Publications.....	17
5.7 Applied Mathematics Series.....	67
5.8 National Standard Reference Data Series.....	68
5.9 Building Science Series.....	69
5.10 Federal Information Processing Standards Publications.....	72
5.11 Voluntary Product Standards.....	72
5.12 Technical Notes.....	73
5.13 Consumer Information Series.....	77
5.14 NBS Interagency Reports.....	78
5.15 Grant/Contract Reports and NBS Patents.....	100
6. Titles and Abstracts of Papers Published in Non-NBS Media.....	110
7. Listing of NBS Papers by Major Subject Areas.....	212
8. Indexes.....	243
8.1 Author Index.....	243
8.2 Key Word Index.....	269
Appendix A. List of Depository Libraries in the United States.....	408
Appendix B. List of District Offices of the U.S. Department of Commerce.....	422



## A GUIDE TO USERS OF THIS PUBLICATION

In addition to the usual author index, a subject index is provided in the form of a permuted key word index. In this type of index the key words in each publication or paper are arranged by shifting each group of key words along the horizontal printing line so that each key word in turn has an opportunity to appear alphabetically. The user is thus able to locate papers of

interest through the subject-related words in the key word index.

The index symbols used in the author and key word indexes are explained in the following three tables. These tables also give the pages on which the abstracts of the various publication series begin.

### SYMBOLS FOR NBS PUBLICATIONS

#### Symbols for the Periodicals

<i>NBS periodicals</i>	<i>Index symbol</i>	<i>Page number</i>
NBS Journal of Research (bimonthly)	J. Res. 87(1)	8
	J. Res. 87(2)	9
	J. Res. 87(3)	9
	J. Res. 87(4)	10
	J. Res. 87(5)	10
	J. Res. 87(6)	10
Journal of Physical and Chemical Reference Data	JPCRD '11(1)	12
	JPCRD 11(2)	12
	JPCRD 11(3)	13
	JPCRD 11(4)	13

#### Symbols for the Nonperiodicals

<i>NBS nonperiodical series</i>	<i>Index symbol</i>	<i>Page number</i>
Monographs	Monogr.	15
Handbooks	H	16
Special Publications	SP	17
Applied Mathematics Series	AMS	67
National Standard Reference Data Series	NSRDS	68
Building Science Series	BSS	69
Federal Information Processing Standards Publications	FIPS PUBS	72
Voluntary Product Standards	VPS	72
Technical Notes	TN	73
Consumer Information Series	CIS	77
NBS Interagency Reports	NBSIR	78
Grant/Contract Reports and Patents	GCR and/or NBS Patent	100

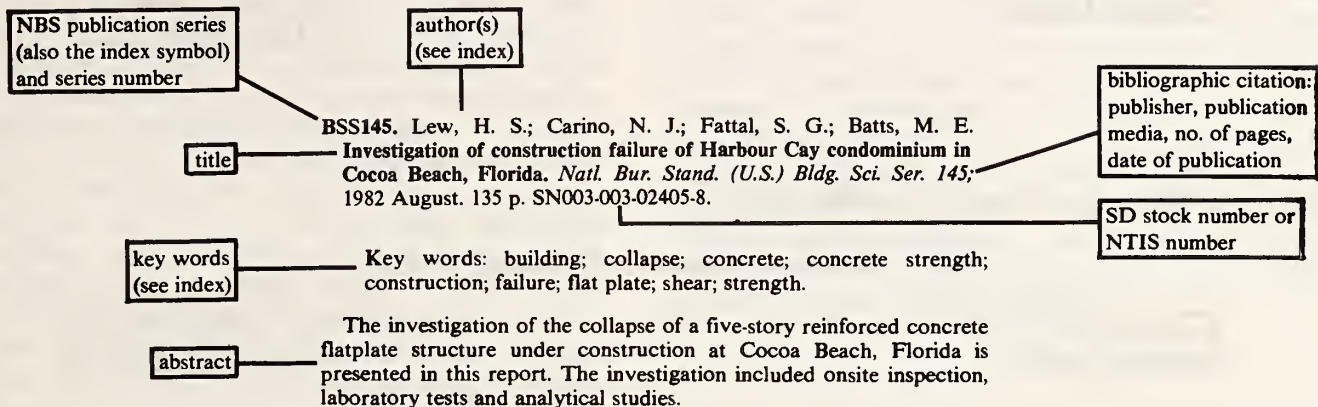
#### Symbols for the Papers Published in Non-NBS Media

<i>NBS Papers Published in Non-NBS Media</i>	<i>Index Symbol</i>	<i>Page number</i>
Professional journals, books, book chapters, proceedings, etc.	5-digit numbers (20775-21541)	110

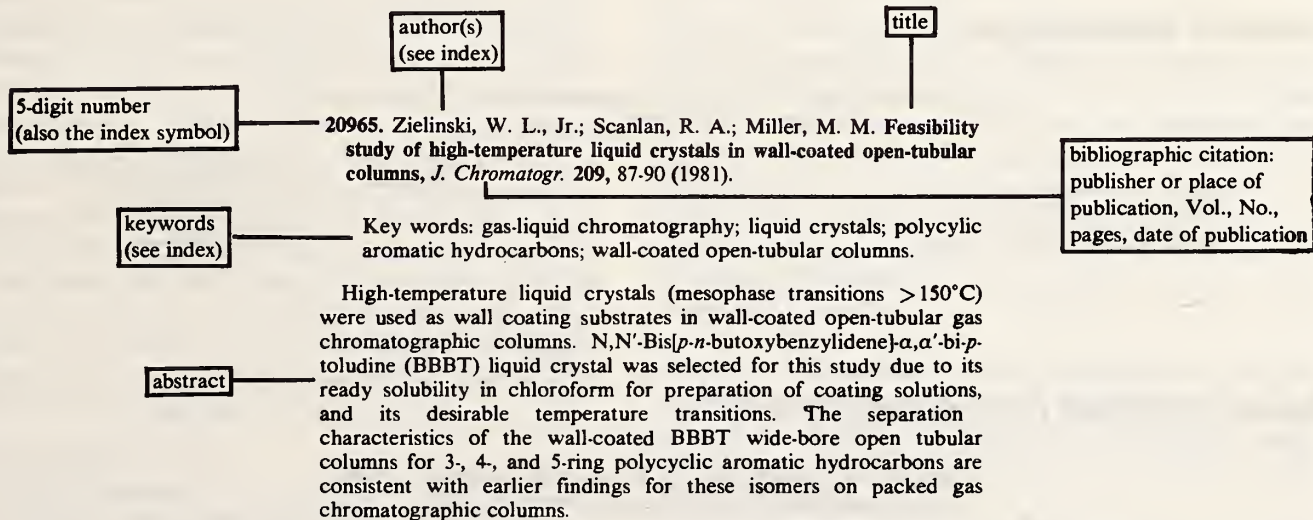
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## ABSTRACTS—SAMPLE ENTRIES

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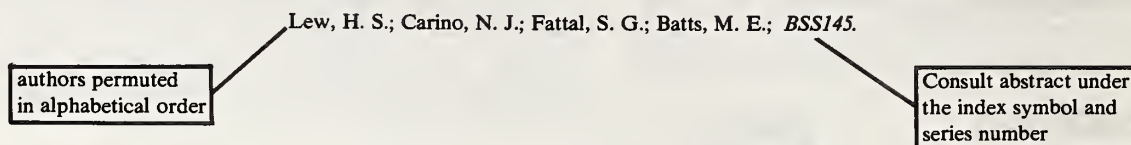


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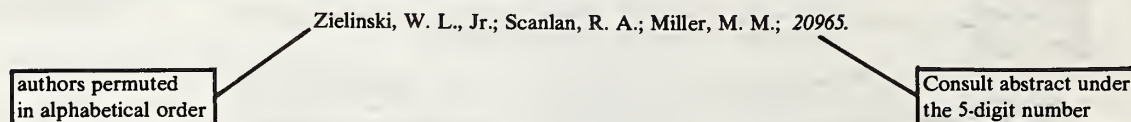


## AUTHOR INDEX—SAMPLE ENTRIES

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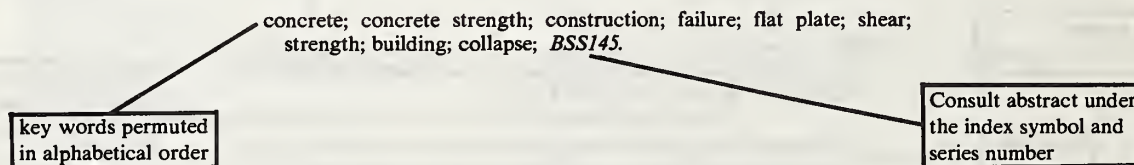


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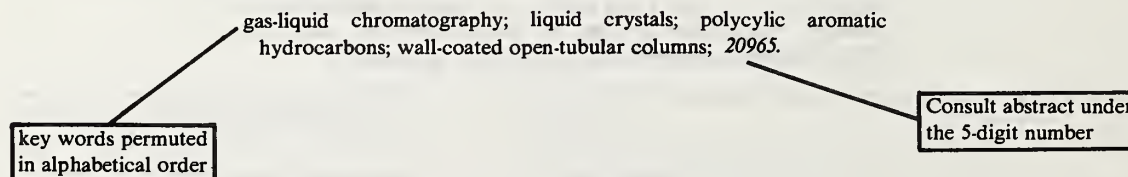


## KEY WORD INDEX—SAMPLE ENTRIES

### Example of NBS-published paper:



### Example of NBS paper published in non-NBS media:





# NBS PUBLICATION PROGRAM

## 1. INTRODUCTION

The formal publications of the National Bureau of Standards are the primary way of communicating the results of NBS programs to its varied technical audiences and the general public. Publications are a major end product of the Bureau's efforts. These take the form of the Bureau's 2 periodicals, its 12 nonperiodical series, and articles in the journals of professional organizations and technological associations.

In 1982, 44,286 pages were published by NBS in 1567 papers. These appeared in the Bureau's own publications series and in non-NBS journals, books, and proceedings. Also included, to complete the record, are those NBS papers published prior to 1982 but not reported in previous issues of this annual catalog.

This annual catalog, *Publications of the National Bureau of Standards*, lists the 1982 output of papers documenting the results of the Bureau's current programs. The various media in which these papers appeared are described in sections 2 and 3.

## 2. PERIODICALS

**Journal of Research**—The Journal of Research of the National Bureau of Standards reports NBS research and development in those disciplines of the physical and engineering sciences in which the Bureau is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Bureau's technical and scientific programs. As a special service to subscribers each issue contains complete citations to all recent Bureau publications in both NBS and non-NBS media. Issued six times a year.

Board of Editors for 1982:

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**DIMENSIONS/NBS**—This magazine was discontinued with the October 1981 issue.

**Journal of Physical and Chemical Reference Data (JPCRD)**—This Journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The Journal provides critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques assess the accuracy of available data in a given technical area. The principal source for the Journal is the National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements normally reported in the primary research literature, or for descriptive or primarily theoretical review articles.

## 3. NONPERIODICALS

**Monographs**—major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

**Handbooks**—recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

**Special Publications**—include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies. Special subject-matter subseries include Semiconductor Measurement Technology (SP400- ), Standard Reference Materials (SP260- ), Precision Measurement and Calibration (SP300- ), Law Enforcement Technology (SP480- ), and Computer Science and Technology (SP500- ).

**Applied Mathematics Series**—mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others in scientific and technical work.

**National Standard Reference Data Series**—provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS, under the authority of the National Standard Data Act (Public Law 90-396). This series supplements the JPCRD described in section 2.



**Building Science Series**—disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

**Federal Information Processing Standards Publications (FIPS PUBS)**—publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

**Voluntary Product Standards**—developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NBS administers the program as a supplement to the activities of the private sector standardizing organizations.

**Technical Notes**—studies or reports complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies. Special subject-matter subseries include Optical Radiation Measurements (TN594- ) and Self Calibrations Manual for Optical Radiation (TN910- ).

**Consumer Information Series**—practical information, based on NBS research and experience, on areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

**NBS Interagency Reports**—a special series of interim or final reports on work performed by NBS for outside sponsors (both Government and non-Government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service (NTIS), Springfield, VA 22161, in paper copy or microfiche form.

**Grant/Contract Reports and NBS Patents**—Grant/Contract Reports are prepared by non-NBS persons or organizations working under grant or contract from the National Bureau of Standards. Those

contract reports not incorporated into the formal NBS publication series are available directly from the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche unless otherwise stated. When ordering a report from NTIS you must order it by the "COM, PB, AD, or N" number as indicated.

Patents are obtained on NBS inventions with high commercial potential, to establish Government ownership of the patent rights. The patents are then made available for the grant of nonexclusive licenses to all qualified applicants. A limited exclusive license may be granted under a particular patent if it appears some period of exclusivity is necessary as an incentive for the investment of risk capital. For information on licensing any of the NBS-held patents, write to the Office of the Legal Adviser, National Bureau of Standards, Washington, DC 20234.

**Papers Published in Non-NBS Media**—reflect significant contributions by NBS authors and are cited annually in this catalog. Citations, key words, and abstracts for these papers are also published bi-monthly in the NBS Journal of Research.

#### 4. DOCUMENT AVAILABILITY AND PURCHASE PROCEDURES

Most publications of the Bureau may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. You may also order through the U.S. Department of Commerce District Office nearest you (see sec. 4.6 and app. B).

Microfiche copies of all recent NBS publications, and paper copies of many nonperiodicals, may be ordered from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

FIPS PUBS, NBS Interagency Reports (NBSIR's), and Grant/Contract Reports (GCR's) are available *only* from the National Technical Information Service, Springfield, VA 22161.

Copies of patents may be obtained from the U.S. Patent and Trademark Office, Washington, DC 20231, for 50 cents each.

Photoduplicated copies of many NBS publications can be purchased from the Library of Congress. For full information concerning this service, write to the Photoduplication Service, Library of Congress, Washington, DC 20540.

**How to Make Remittances to the Superintendent of Documents.** Order forms are included at the end of this publication. Remittances for publications should be mailed to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402,



by money order, check, Master Card, or VISA. Be sure to give your credit card number and expiration date on all orders. Postage stamps will not be accepted. Publications cannot be mailed before remittances are received. *Foreign remittances should be made either by international money order, draft on an American or Canadian bank, or UNESCO coupons.*

The letter symbol, publication number, full title of the publication, and SD stock number **MUST** be given when ordering. The Superintendent of Documents allows a discount of 25 percent on orders of 100 or more copies of one publication, when mailed to a single address.

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No charge is made for postage on documents sent to points in the United States and its possessions. In computing foreign postage, the charge is approximately one-fourth of the current selling price of the publication. The charge is to cover special handling required to comply with customs and international mailing regulations.

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SD and NTIS order forms are included at the end of this publication for your convenience in ordering.

#### 4.1 NBS PERIODICAL SUBSCRIPTION RATES

##### Journal of Research of the National Bureau of Standards

	Domestic <sup>1</sup>	Foreign <sup>2</sup>
paper covers	\$18	\$22.50
bound volume (1 per yr)	(3)	(3)

NOTE—Send order with remittance to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

<sup>1</sup> United States and its possessions.

<sup>2</sup> Foreign price includes the cost of the publication and postage.

<sup>3</sup> Prices vary. The Superintendent of Documents will furnish prices on request.

##### Journal of Physical and Chemical Reference Data

	U.S.A. Canada Mexico	Foreign (surface mail)	Optional Air Freight	
			Europe Mideast N. Africa	Asia and Oceania
Members (of ACS or of AIP member or affiliated society)	\$42	\$48	\$60	\$68
Regular rate	\$170	\$176	\$188	\$196

NOTE—Subscriptions should be sent with payment to the Office of the Controller, American Chemical Society, 1155 Sixteenth Street NW., Washington, DC 20036.

#### 4.2 PRICES FOR NONPERIODICALS

Current price information for publications with SD stock numbers (SN003-003 ) can be obtained from the Order and Inquiry Section, U.S. Government Printing Office, Washington, DC 20402 (telephone: 202-783-3238). (Add one-fourth additional for foreign orders.)

Current price information for publications with NTIS order numbers can be obtained from the NTIS Order Desk (telephone: 703-487-4650).

#### 4.3 FORMER NBS REFERENCE PUBLICATIONS

Certain NBS publications are out of print because they have been replaced or partially replaced by material issued by other organizations. NBS is able to offer the following information on some of these publications:

*Circular 410, National Standard Petroleum Oil Tables.* Information in this Circular has been incorporated in the American Edition—ASTM Petroleum Measurement Tables issued as PCN12-4125-10-12 by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103. Available at \$30, 20 percent discount to ASTM members. Tables 5 and 7 of the ASTM Petroleum Measurement Tables may also be purchased from the ASTM in separate reprint form at \$2.25 and \$2 per copy, respectively.

*Circular 438, Static Electricity.* The National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, has issued a publication by the same title, available from them as NFPA Publication 77, \$6.

*Circular 499, Nuclear Data.* Replaced by Atomic Data and Nuclear Data Tables, published by Academic Press, 111 Fifth Avenue, New York, NY 10003. Available bi-monthly for \$78.



*Circular 547, Section 1, Precision Laboratory Standards of Mass Laboratory-Weights.* Information in this Circular has been incorporated in the ANSI/ASTM E 617-78, Standard Specification for Laboratory Weights and Precision Mass Standards issued by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, Attn: Sales, for \$4.

*Circular 576, Automotive Antifreezes.* For information on this subject consult American National Standards Institute, 1430 Broadway, New York, NY 10018.

*Circular 577 and Supplement, Energy Loss and Range of Electrons and Positrons.* These have been superseded by NASA Special Publication 3012, available from the National Technical Information Service, Springfield, VA 22161, as N65-12506, at \$13.50 hardcopy and N67-14099, at \$7.50 hardcopy and \$4 microfiche.

*Miscellaneous Publication 179, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.* The American National Standards Institute, 1430 Broadway, New York, NY 10018, has issued a publication on this subject. Available from them as A58.1-1972, at \$9.75.

*Miscellaneous Publication 187, Directory of Commercial and College Laboratories.* A new revised Directory of Testing Laboratories, issued as STP 333E, is published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, at \$15.

*NBS Handbook 28, Parts 1, 2, and 3, Screw Thread Standards.* Federal Government responsibility for screw thread standards has been transferred to the General Services Administration (GSA). Standards will be promulgated by the GSA as Federal Standard 28. Copies of Federal Standard H28 are available from: GSA Specifications, Bldg. 197, Washington Navy Yard, Washington, DC 20407 for \$25.80 per set. Telephone: 202-472-2205. Questions regarding administration of the program should be addressed to General Products Division (FREGM), General Services Administration (Federal Supply Service), Washington, DC 20406. Telephone: 703-557-7595.

*Handbook 30, National Electrical Safety Code (also H81 and its Supplements and H110-1).* All NBS publications on this subject have been superseded by National Electrical Safety Code, 1981 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2-1977, at \$9.75.

*Handbook 46, Code for Protection Against Lightning.* A United States of America Standards Institute Code for Protection Against Lightning (NFPA-78-1980) is available from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at \$5.75, as ANSI/NFPA-78-1980.

*Handbook 48, Control and Removal of Radioactive Contamination in Laboratories.* Reprints of this Handbook can be purchased as NCRP Report 8 at \$6 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 49, Recommendations for Waste Disposal Phosphorus-32 and Iodine-131 for Medical Users.* Reprints of this Handbook can be purchased as NCRP Report 9 at \$6 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 53, Recommendations for the Disposal of Carbon-14 Wastes.* Reprints of this Handbook can be purchased as NCRP Report 12 at \$6 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 55, Protection Against Betatron-Synchrotron Radiations up to 100 Million Electron Volts,* February 26, 1954 has been combined with NBS Handbook 97. Available as NCRP Report 51, Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities from NCRP Publications, P.O. Box 30175, Washington, DC 20014, at \$9.

*Handbook 58, Radioactive Waste Disposal in the Ocean.* Reprints of this Handbook can be purchased as NCRP Report 16 at \$6 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 59, Permissible Dose from External Sources of Ionizing Radiations.* Reprints of this Handbook can be purchased as NCRP Report 39 at \$8 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 63, Protection Against Neutron Radiation up to 30 MeV.* Reprints of this Handbook can be purchased as NCRP Report 38 at \$9 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 65, Safe Handling of Bodies Containing Radioactive Isotopes.* Reprints of this Handbook can be purchased as NCRP Report 37 at \$8 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 69, Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure.* Reprints of this Handbook can be purchased as NCRP Report 22 at \$6 from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 71, Specifications for Dry Cells and Batteries.* Available as ANSI C18.1-1979 from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at \$6.

*Handbook 73, Protection Against Radiations from Sealed Gamma Sources (Supersedes H54).* Reprints of this Handbook can be purchased as NCRP Report 40 at \$8



from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 74, Building Code Requirements for Reinforced Masonry.* The American National Standards Institute, 1430 Broadway, New York, NY 10018 has issued a publication on this subject. Available from them as ANSI/NBS Handbook H74-1960 (R1970), at \$4.50.

*Handbook 75, Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays.* Reprints of this Handbook can be purchased as NCRP Report 25 at \$6 per copy from NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 76, Medical X-Ray Protection Up to Three Million Volts.* Now available as NCRP 33. Purchase from NCRP Publications, P.O. Box 30175, Washington, DC 20014, at \$7.

*Handbook 80, a Manual of Radioactivity Procedures.* Reprints of this Handbook are available as NCRP Report 58, for paper copy at \$14, and buckram at \$16. For more information write to NCRP Publications, P.O. Box 30175, Washington, DC 20014.

*Handbook 81 and Its Supplements, Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines* (also H30 and H110-1). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1981 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2-1977, at \$9.75.

*Handbook 84, Radiation Quantities and Units.* Reprints of this Handbook can be purchased as ICRU Report 33 at \$8.50 from ICRU Publications, P.O. Box 30165, Washington, DC 20014.

*Handbook 85, Physical Aspects of Irradiation.* Reprints of this Handbook can be purchased as ICRU Report 10b at \$5.50 per copy from ICRU Publications, P.O. Box 30165, Washington, DC 20014.

*Handbook 86, Radioactivity.* Reprints of this Handbook can be purchased as ICRU Report 10C, Radioactivity at \$4 from ICRU Publications, P.O. Box 30165, Washington, DC 20014.

*Handbook 87, Clinical Dosimetry.* Information in this Handbook has been incorporated in ICRU Report 23 at \$8 per copy; ICRU Report 24 at \$8 per copy; and ICRU Report 29 at \$10 per copy from ICRU Publications, P.O. Box 30165, Washington, DC 20014.

*Handbook 88, Radiobiological Dosimetry.* Reprints of this Handbook can be purchased as ICRU Report 30, Quantitative Concepts and Dosimetry in Radiobiology

at \$10 from ICRU Publications, P.O. Box 30165, Washington, DC 20014.

*Handbook 89, Methods of Evaluating Radiological Equipment and Materials.* Reprints of this Handbook can be purchased as ICRU Report 10F at \$3.50 from ICRU Publications, P.O. Box 30165, Washington, DC 20014.

*Handbook 96, Inspection of Processed Photographic Record Films for Aging Blemishes.* Reprints of this Handbook can be purchased as PH 1.28-1976 at \$5.50 from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

*Handbook 97, Shielding for High-Energy Electron Accelerator Installations.* July 1, 1964, has been combined with NBS Handbook 55. Available as NCRP Report 51, Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities from NCRP Publications, P.O. Box 30195, Washington, DC 20014, at \$9.

*Handbook 102, ASTM Metric Practice Guide.* Available as ANSI/ASTM E380-76 from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at \$4.

*Handbook 110-1, National Electrical Safety Code.* Part 1. Rules for Installation and Maintenance of Electric Supply and Communication Lines (also H30 and H81 and its Supplements). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1981 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2-1977 at \$9.75.

*Technical Note 938, Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction,* has been superseded by ASTM E621-78, Standard Practice of the Use of Metric (SI) Units in Building Design and Construction. It is available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, at \$4.

#### 4.4 ANNOUNCEMENTS OF NBS PUBLICATIONS

The National Bureau of Standards and the agencies mentioned below regularly announce NBS publications:

*NBS Journal of Research.* The Journal carries a listing of all NBS Publications as issued. See section 4.1 for subscription information.

*Monthly Catalog of United States Government Publications.* Issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription, with consolidated annual index, \$90; \$112.50 foreign.



**Catalog of All Publications.** There are almost 20,000 titles available from the Superintendent of Documents. It does not publish a single hardcopy catalog listing all of these items. It does, however, publish a total sales catalog in microform. The GPO Sales Publications Reference File (PRF) is a subscription that catalogs all publications currently offered for sale by the Superintendent of Documents. It is available only on microfiche. The service consists of bimonthly mailings of the complete master file (approximately 350 fiche) and monthly mailings of a single fiche containing new publications. Annual subscriptions are available for \$125.00 to domestic addresses and for \$156.25 to foreign addresses. The list ID is (PRF). To order this item use the forms in the back of this catalog.

**Commerce Publications Update.** Biweekly announcement of publications of the Department of Commerce. Lists titles and prices of National Bureau of Standards publications, as well as those of other offices of the Department of Commerce. Contact the Editorial Policy and Review Division, Office of Publications, U.S. Department of Commerce, Washington, DC 20230, for information on how to receive this listing.

**NBS Catalogs of NBS Publications.** These catalogs list all NBS publications through December 31, 1981. The catalogs are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, or NTIS, Springfield, VA 22161, or may be consulted in a library which maintains sets of National Bureau of Standards publications.

Circular 460: Publications of the National Bureau of Standards 1901 to June 30, 1947, 375 pages including subject and author indexes. Brief abstracts are included for the period January 1, 1941 to June 30, 1947 .....	*
Supplement to Circular 460: Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957. 373 pages, including subject and author indexes .....	*
Miscellaneous Publication 240: Publications of the National Bureau of Standards, July 1, 1957 to June 30, 1960. First NBS Catalog to include titles of papers published in outside journals 1950 to 1959, 391 pages including subject and author indexes .....	*
Supplement to Miscellaneous Publication 240: Publications of the National Bureau of Standards published by NBS, July 1960 through June 1966; published by others, 1960 through 1965. 740 pages including subject and author indexes .....	*
Special Publication 305: Publications of the National Bureau of Standards, published by NBS, July 1966 through December 1967; published by others, 1966-1967. 223 pages, including author and key word indexes .....	*
Supplement 1 to Special Publication 305: Publications of the National Bureau of Standards, 1968 through 1969. 497 pages including author and key word indexes .....	*
Supplement 2 to Special Publication 305: Publications of the National Bureau of Standards, 1970. 378 pages including author and key word indexes .....	*
Supplement 3 to Special Publication 305: Publications of the National Bureau of Standards, 1971. 342 pages including author and key word indexes .....	*
Supplement 4 to Special Publication 305: Publications of the National Bureau of Standards, 1972. 449 pages including author and key word indexes .....	*

Supplement 5 to Special Publication 305: Publications of the National Bureau of Standards, 1973. 349 pages including author and key word indexes .....	*
Supplement 6 to Special Publication 305: Publications of the National Bureau of Standards, 1974. 523 pages including author and key word indexes .....	*
Supplement 7 to Special Publication 305: Publications of the National Bureau of Standards, 1975. 595 pages including author and key word indexes .....	*
Supplement 8 to Special Publication 305: Publications of the National Bureau of Standards, 1976. 728 pages including author and key word indexes .....	*
Supplement 9 to Special Publication 305: Publications of the National Bureau of Standards, 1977. 601 pages including author and key word indexes .....	\$12
Supplement 10 to Special Publication 305: Publications of the National Bureau of Standards, 1978. 679 pages including author and key word indexes .....	\$14
Supplement 11 to Special Publication 305: Publications of the National Bureau of Standards, 1979. 615 pages including author and key word indexes .....	\$14
Supplement 12 to Special Publication 305: Publications of the National Bureau of Standards, 1980. 634 pages including author and key word indexes .....	\$13
Supplement 13 to Special Publication 305: Publications of the National Bureau of Standards, 1981. 474 pages including author and key word indexes .....	\$12
Supplement 14 to Special Publication 305: Publications of the National Bureau of Standards, 1982. 430 pages including author and key word indexes .....	
Special Publication 535, Catalog of NBS Publications, 1966-1976. Volumes 1 (2 parts) and 2 (2 parts). Consolidated reprint of bibliographic citations, abstracts, and key words from NBS SP305, and its Supplements 1-8.	
SP535, Volume 1 .....	\$32
SP535, Volume 2 .....	\$30

\*Available by purchase from the National Technical Information Service, Springfield, VA 22161.

#### 4.5 DEPOSITORY LIBRARIES IN THE UNITED STATES

The Superintendent of Documents, U.S. Government Printing Office, is authorized by law to furnish Government publications to designated depository libraries (see app. A).

Under Provisions of Title 44 of the United States Code, certain libraries are designated depositories for Government publications. Through them, Federal Government documents are made available to residents of every State, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands. Distribution to the libraries is made by the Superintendent of Documents.

It is sometimes impossible to obtain desired publications by purchase from the Superintendent of Documents. Stocks may have been exhausted or the document may be permanently out of print. The depositories provide a valuable service by keeping such publications permanently available. Every Government publication cannot be consulted at all depository libraries. Designated Regional Depositories are required



to receive and retain one copy of all Government publications made available to depository libraries either in printed or microfacsimile form. All other libraries are allowed to select the classes of publications best suited to the interest of their particular clientele.

These libraries are now receiving selected publication series of the National Bureau of Standards for general reference use. Whether a given library has a copy of a particular publication can be determined by inquiring at the library.

#### **4.6 U.S. DEPARTMENT OF COMMERCE DISTRICT OFFICES**

U.S. Department of Commerce District Offices (see app. B) provide ready access at the local level to the services of the Department of Commerce and its reports, publications, statistical statements, and surveys. Most District Offices serve as official sales agents of the Superintendent of Documents, U.S. Government Printing Office, making available for purchase locally a wide range of Government business publications. The reference library maintained by each District Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

## 5. TITLES AND ABSTRACTS OF NBS PUBLICATIONS, 1982

### 5.1 PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 87, JANUARY-DECEMBER 1982

#### January-February 1982

Moore, L. J.; Murphy, T. J.; Barnes, I. L.; Paulsen, P. J. **Absolute isotopic abundance ratios and atomic weight of a reference sample of strontium.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 1-8; 1982 January-February.

Key words: absolute ratios; atomic weight; isotopic abundances; strontium.

Absolute values have been obtained for the isotopic abundance ratios of a reference sample of strontium using solid sample thermal ionization mass spectrometry. Samples of independently known isotopic composition prepared from chemically pure and nearly isotopically pure separated strontium isotopes were used to calibrate the mass spectrometry. The resulting absolute  $^{88}\text{Sr}/^{86}\text{Sr}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$ , and  $^{84}\text{Sr}/^{86}\text{Sr}$  ratios are  $8.3786 \pm 0.0033$ ,  $0.71034 \pm 0.00026$ , and  $0.05655 \pm 0.00014$  respectively which yields atom percents of:  $^{88}\text{Sr} = 82.5845 \pm 0.0066$ ,  $^{87}\text{Sr} = 7.0015 \pm 0.0026$ ,  $^{86}\text{Sr} = 9.8566 \pm 0.0034$ , and  $^{84}\text{Sr} = 0.5574 \pm 0.0015$ . The atomic weight calculated from these abundances is  $87.61681 \pm 0.00012$ . The indicated uncertainties are overall limits of error based on 95 percent confidence limits for the mean and allowances for the effects of possible systematic error.

Powell, L. J.; Murphy, T. J.; Gramlich, J. W. **The absolute isotopic abundance and atomic weight of a reference sample of silver.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 9-19; 1982 January-February.

Key words: absolute ratios; atomic weight; Faraday constant; isotopic abundance; mass spectrometry; silica gel; silver; silver iodide.

The atomic weight of a reference sample of silver has been determined by mass spectrometry, with an uncertainty of one part in  $10^6$ , using a single filament silica gel procedure. Accurately known quantities of chemically pure  $^{107}\text{Ag}$  and  $^{109}\text{Ag}$  were mixed to produce standards of known isotopic composition for calibration of the mass spectrometer. The absolute isotopic ratio of the reference sample of silver is  $^{107}\text{Ag}/^{109}\text{Ag} = 1.07638 \pm 0.00022$  yielding an atomic weight of  $107.86815 \pm 0.00011$ . The indicated uncertainties represent an overall limit of error at the 95 percent confidence level which is the sum of the uncertainty components for the ratio determined and the components covering effects of known sources of possible systematic error.

Bower, V. E.; Davis, R. S.; Murphy, T. J.; Paulsen, P. J.; Gramlich, J. W.; Powell, L. J. **Recalculation of the Faraday constant due to a new value for the atomic weight of silver.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 21-22; 1982 January-February.

Key words: atomic weight; atomic weight of silver; coulometer; electrochemical equivalent; Faraday constant; fundamental constants; silver; silver coulometer.

A report of the Faraday constant as determined at NBS via silver coulometry and atomic weight measurements is presented. The uncertainty of the reported results represents a five-fold improvement over measurements made at NBS 20 years ago. The result should contribute to an analysis of the self-consistency of several other fundamental constants measurements. Experimental details have been reported in other publications which are cited in the text.

Cage, M. E.; Davis, R. S. **An analysis of read-out perturbations seen on an analytical balance with a swinging pan.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 23-45; 1982 January-February.

Key words: analytical balance; balance dynamics; balance sensitivity; balance suspension; knife-edge bearings; Mathieu's equation; single-pan balance.

An analysis of the dynamic behavior of a single-pan mechanical balance is presented. In particular, errors caused by a swinging pan are analyzed in detail. Results point to a large effect which, though apparently not previously appreciated, is nevertheless easily verified

experimentally. It is suggested that this effect can be reduced to insignificance in a balance whose beam is servo-controlled to an angle perpendicular to the local gravitational field.

Schoonover, R. M. **A 30 kg capacity high precision load cell mass comparator.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 47-48; 1982 January-February.

Key words: constant loading; high precision; load cell; mass comparator; substitution weighing; weighing.

Described here are simple means to fabricate a 30 kg mass comparator based on an ordinary direct reading load cell. The mass comparator performs with a precision of 1 ppm.

Younger, S. M. **Electron impact ionization of lithium.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 49-51; 1982 January-February.

Key words: electron-atom scattering; electron impact ionization; lithium atom.

The electron impact ionization cross section of the neutral lithium atom has been calculated in a distorted wave exchange approximation. The total cross section is in good agreement with available experimental data at incident electron energies above 10 eV. Analytic fits are provided for the 1s and 2s subshell partial cross sections.

Rice, J. **An approach to peak area estimation.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 53-65; 1982 January-February.

Key words: linear models; minimax; peak area; smoothing; spectroscopy; splines; statistical methods.

We consider the problem, arising in nuclear spectroscopy, of estimating peak areas in the presence of a baseline of unknown shape. We analyze a procedure that chooses the baseline to be as smooth as is consistent with the data and note that the estimates have a certain minimax optimality. Expressions are developed for the systematic and random errors of the estimate, and some large sample approximations are derived. Procedures for choosing a smoothing parameter are developed and illustrated by simulations.

Spiegelman, C. **A note on the behavior of least squares regression estimates when both variables are subject to error.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 67-70; 1982 January-February.

Key words: errors in variable; functional; large sample, convex; regression; statistical methods; structural.

For the errors in variables model  $X=U+V$ ,  $Y=\beta f(U)+W$ , sufficient conditions are given for the L.S. limiting estimate of  $\beta$  to satisfy  $P(\hat{\beta}/\beta < 1) = 1$  or  $P(\hat{\beta}/\beta > 1) = 1$  as the sample size tends to infinity.

Spiegelman, C. **A univariate inequality for medians.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 71-74; 1982 January-February.

Key words: concave; convex; inequality; majorization; median; statistical methods.

An inequality is provided for medians which is an analog of a theorem due to Karamata, dealing with majorization.

Goldman, A. J.; Byrd, R. H. **Minimum-loop realization of degree sequences.** *J. Res. Natl. Bur. Stand. (U.S.).* 87(1): 75-78; 1982 January-February.

Key words: degree sequence; graph; incidence sequence; loopless graph; partition.

Given a finite sequence  $D$  of nonnegative integers, let  $M(D)$  denote its maximum element and  $S(D)$  its sum. It is known that  $D$  is realizable as a degree sequence by some graph if and only if  $S(D)$  is even, and by a loopless graph if and only if the even integer  $S(D) - 2M(D) > 0$ . Here it is shown that if the even integer  $2M(D) - S(D)$  is positive, then



one-half this integer is the minimum number of loops in graphs realizing  $D$ , and that the minimum-loop realization is unique. These results are extended to a more general loop-cost minimization problem in which loops incident at different vertices can have different costs. The possible numbers of loops, in graphs realizing  $D$ , are also determined.

### March-April 1982

Tewari, Y. B.; Miller, M. M.; Wasik, S. P. Calculation of aqueous solubility of organic compounds. *J. Res. Natl. Bur. Stand. (U.S.)* 87(2): 155-158; 1982 March-April.

Key words: activity coefficients; gas chromatography; octanol/water partition coefficients; solubility parameters.

The aqueous solubility of 14 organic solutes has been calculated from their octanol/water partition coefficient and from their solute activity coefficient in octanol at infinite dilution. The solute activity coefficients were calculated from the Flory-Huggins and Hildebrand-Scatchard (FH-HS) equations and were found to be in good agreement with the activity coefficients determined from GC specific retention volume measurements. The calculated solubilities were in good agreement with the experimental solubilities.

Ditmars, D. A.; Ishihara, S.; Chang, S. S.; Bernstein, G.; West, E. D. Enthalpy and heat-capacity standard reference material: Synthetic sapphire ( $\alpha$ - $\text{Al}_2\text{O}_3$ ) from 10 to 2250 K. *J. Res. Natl. Bur. Stand. (U.S.)* 87(2): 159-163; 1982 March-April.

Key words: aluminum oxide; corundum; drop calorimetry; enthalpy; heat capacity; high temperature; standard reference material; synthetic sapphire.

Heretofore unpublished enthalpy data which were used in the derivation of smooth enthalpy and heat-capacity data for NBS SRM 720 ( $\alpha$ - $\text{Al}_2\text{O}_3$ , heat capacity and enthalpy standard) are presented along with some details of the high-temperature experiments. Recent NBS low-temperature measurements on SRM 720 are smoothed by a least-squares spline technique and a revised table of certified values for enthalpy and heat capacity of  $\alpha$ - $\text{Al}_2\text{O}_3$  from 10 K to near the melting point (2250 K) is presented.

Rehm, R. G.; Baum, H. R.; Barnett, P. D. Buoyant convection computed in a vorticity, stream-function formulation. *J. Res. Natl. Bur. Stand. (U.S.)* 87(2): 165-185; 1982 March-April.

Key words: buoyant convection; finite difference computations; fire-enclosure; fluid flow; Lanczos smoothing; partial differential equations; stream function; vorticity.

Model equations describing large scale buoyant convection in an enclosure are formulated with the vorticity and stream function as dependent variables. The mathematical model, based on earlier work of the authors, is unique in two respects. First, it neglects viscous and thermal conductivity effects. Second the fluid is taken to be thermally expandable: large density variations are allowed while acoustic waves are filtered out. A volumetric heat source of specified spatial and temporal variation drives the flow in a two-dimensional rectangular enclosure. An algorithm for solution of the equations in this vorticity, stream-function formulation is presented. Results of computations using this algorithm are presented. Comparison of these results with those obtained earlier by the authors using a finite difference code to integrate the primitive equations show excellent agreement. A method for periodically smoothing the computational results during a calculation, using Lanczos smoothing, is also presented. Computations with smoothing at different time intervals are presented and discussed.

### May-June 1982

Schoonover, R. M. The density determination of small solid objects by a simple float method—I. *J. Res. Natl. Bur. Stand. (U.S.)* 87(3): 197-206; 1982 May-June.

Key words: density measurement; float method; small solid objects; solid object density scale.

The density determination of a small solid object with a mass of only a few hundred milligrams is always a difficult and often an elusive measurement. The advent of highly accurate hydrostatic weighing techniques and the density scale based on solid objects are utilized in a two liquid float method presented here that incorporates the advantages of this technology. The resulting measurement is an absolute determination of density with an uncertainty of 500 ppm and has a density range from 2.3 g/cm<sup>3</sup> (silicon) to 21.5 g/cm<sup>3</sup> (platinum). The instrument was used to measure the variation in the alloy density of nickel with respect to phosphorus content and to determine the density of optical fiber glass.

Davis, R. S. The density determination of small solid objects by a simple float method—II. *J. Res. Natl. Bur. Stand. (U.S.)* 87(3): 207-209; 1982 May-June.

Key words: density; density changes; density of solids; small samples.

The measurement of density changes in solid samples of less than one gram is often of practical interest. We describe here such relative measurements having a precision of a few parts in 10<sup>4</sup> using a newly reported apparatus. Comparisons of results with theory are presented.

Domen, S. R. An absorbed dose water calorimeter: Theory, design, and performance. *J. Res. Natl. Bur. Stand. (U.S.)* 87(3): 211-235; 1982 May-June.

Key words: absorbed dose; calorimeter; convection; heat defect; radiation chemistry; thermistor; water.

Two calibrated thermistors sandwiched between two insulative polyethylene films were immersed in a 30 cm cube of water having a low thermal diffusivity. The product of the specific heat of water and temperature rise gave the combined effect of the local absorbed dose and any heat defect at a position along a temperature profile produced by cobalt-60 irradiation. The dose rate was near 18 mGy/s and exposure times were 3 min. The standard deviation for a daily set of measurements was about 0.6 percent. Calculations showed that conductive heat transfer produced a negligible effect at the position of measurement along the beam axis. Tests showed the absence of convection.

Temperature drifts before irradiation were quickly controlled by changing the power dissipated in the water between two immersed electrodes. Reproducible measurements were obtained in distilled water supplies that had a wide range of impurities. Measurements, after saturating the water with nitrogen or oxygen, showed no difference. A difference of 0.6 percent would have been easily detectable. Tests with several chemicals added to water showed some unexpected results and changes in the measured absorbed dose rate versus accumulated dose. The measured absorbed dose rate in distilled water under the conditions described was 3.5 percent higher than that determined from measurements with a graphite calorimeter.

Pine, A. S.; Lafferty, W. J. Torsional splittings and assignments of the Doppler-limited spectrum of ethane in the C-H stretching region. *J. Res. Natl. Bur. Stand. (U.S.)* 87(3): 237-256; 1982 May-June.

Key words: C-H stretching region; difference-frequency laser; Doppler-limited resolution; ethane; ground state constants; infrared spectrum; low temperature spectrum; torsional splittings.

The Doppler-limited absorption spectrum of the C-H stretching region of ethane has been recorded at  $T \approx 119$  K with a tunable difference-frequency laser spectrometer. The strong torsional hot band structure at room temperature is eliminated at 119 K, and the enhanced resolution from the Doppler width reduction allows us to observe small torsional splittings. The two fundamentals in the region,  $\nu_7$ , a perpendicular band and,  $\nu_8$ , a parallel band have been essentially completely assigned as have a large number of transitions in the parallel component of the  $\nu_8 + \nu_{11}$  combination band. A number of perturbations of both global and local nature have been observed. The complete spectrum and a listing of transition wavenumbers, intensities and assignments are presented here to facilitate identification and quantitative analysis of ethane in a variety of monitoring applications. Precise ground state rotational constants have been determined from combination differences.

Doane, L. M.; Fatiadi, A. J. Mechanism of the electrical conductivity



in potassium croconate violet. *J. Res. Natl. Bur. Stand. (U.S.)* 87(3): 257-260; 1982 May-June.

Key words: conductivity; croconates; crystallographic; electrical; electrochemical; mechanism;  $\pi$ -acceptors; semiconduction.

Based on crystallographic analysis and results of the solution electrochemistry, a mechanism for electron conduction is proposed.

## July-August 1982

Roder, H. M. The thermal conductivity of oxygen. *J. Res. Natl. Bur. Stand. (U.S.)* 87(4): 279-310; 1982 July-August.

Key words: hot wire; oxygen; pressure temperature; thermal conductivity; transient.

The paper presents new experimental measurements of the thermal conductivity of oxygen for thirteen isotherms at temperatures from 78 to 310 K with pressures to 70 MPa and densities from 0 to 40 mol/L. The measurements were made with a transient hot wire apparatus and they cover a wide range of physical states including the dilute gas, the moderately dense gas, the near critical region, the compressed liquid states, and the vapor at temperatures below the critical temperature. The thermal conductivity surface is represented with an equation that is based in part on an existing correlation of the dilute gas. The data are compared with the experimental measurements of others through the new correlation. The new measurements show that the critical enhancement extends to quite high temperatures, about 300 K. The precision ( $2\sigma$ ) of the oxygen measurements is between 0.5 and 0.8 percent for wire temperature transients of 4 to 5 K, while the accuracy is estimated to be 1.5 percent.

Wasik, S. P.; Tewari, Y. B.; Miller, M. M.; Purnell, J. H. Measurements of the octanol/water partition coefficient by chromatographic methods. *J. Res. Natl. Bur. Stand. (U.S.)* 87(4): 311-315; 1982 July-August.

Key words: activity coefficients; alkylbenzenes; gas chromatography; octanol/water partition coefficients.

A theoretical relationship is developed to provide a quantitative definition of hydrophobicity using established theoretical and semi-empirical relationships. A method of predicting partition coefficients of relatively water-insoluble third components between water and an immiscible second component is devised and tested. Comparison with experimental data for four classes of compounds in the water/*n*-octanol system at 25°C shows excellent agreement, indicating that values for substances for which direct determination is experimentally precluded can be calculated with confidence.

Stoer, J. Curve fitting with clothoidal splines. *J. Res. Natl. Bur. Stand. (U.S.)* 87(4): 317-346; 1982 July-August.

Key words: approximation; clothoids; computer-aided design; Cornu-spirals; curvature; curve fitting; Fresnel-integrals; interpolation; splines.

Clothoids, i.e., curves  $Z(s)$  in  $R^2$  whose curvatures  $\kappa(s)$  are linear fitting functions of arclength  $s$ , have been used for some time for curve fitting purposes in engineering applications. The first part of the paper deals with some basic interpolation problems for clothoids and studies the existence and uniqueness of their solutions.

The second part discusses curve fitting problems for clothoidal splines, i.e.,  $C^2$ -curves, which are composed of finitely many clothoids. An iterative method is described for finding a clothoidal spline  $Z(s)$  passing through given points  $Z_i \in R^2, i=0, 1, \dots, n+1$ , which minimizes the integral  $\int_2 \kappa(s)^2 ds$ .

This algorithm is superlinearly convergent and needs only  $O(n)$  operations per iteration. A similar algorithm is given for a related problem of smoothing by clothoidal splines.

## September-October 1982

Paule, R. C.; Mandel, J. Consensus values and weighting factors. *J. Res. Natl. Bur. Stand. (U.S.)* 87(5): 377-385; 1982 September-October.

Key words: ANOVA (within-between); components of variance; consensus values; design of experiments; pooling of variance; weighted average; weighted least squares regression.

A method is presented for the statistical analysis of sets of data which are assembled from multiple experiments. The analysis recognizes the existence of both within group and between group variabilities, and calculates appropriate weighting factors based on the observed variability for each group. The weighting factors are used to calculate a "best" consensus value from the overall experiment. The technique for obtaining the consensus value is applicable to either the determination of the weighted average value, or to the parameters associated with a weighted least squares regression problem. The calculations are made by using an iterative technique with a truncated Taylor series expansion. The calculations are straightforward, and are easily programmed on a desktop computer.

An examination of the observed variabilities, both within groups and between groups, leads to considerable insight into the overall experiment and greatly aids in the design of future experiments.

Mangum, B. W.; Furukawa, G. T. Report on the Sixth International Symposium on Temperature. *J. Res. Natl. Bur. Stand. (U.S.)* 87(5): 387-406; 1982 September-October.

Key words: fixed points; symposium; temperature scale; thermometers; thermometry.

This is a report on the Sixth International Symposium of Temperature which was held in Washington, DC, USA, March 15-18, 1982. Included is a brief introduction discussing the timeliness of the symposium, its sponsors, and the publication of the proceedings. The remainder of the report is devoted to a summary of the Plenary and Technical sessions of the symposium.

Clifton, J. R.; Carino, N. J. Nondestructive evaluation methods for quality acceptance of installed building materials. *J. Res. Natl. Bur. Stand. (U.S.)* 87(5): 407-438; 1982 September-October.

Key words: building materials; concrete; evaluation; in-place testing; inspection; nondestructive testing; quality assurance.

A review of methods developed for the nondestructive evaluation (NDE) of building materials is presented. The generic features of NDE methods are discussed. This is followed by descriptions of specific methods. The principles underlying the operation of the methods are described, along with their typical applications, advantages, and limitations. A table is included summarizing the characteristics of various NDE methods.

## November-December 1982

Croarkin, M. C.; Yang, G. L. Acceptance probabilities for a sampling procedure based on the mean and an order statistic. *J. Res. Natl. Bur. Stand. (U.S.)* 87(6): 485-511; 1982 November-December.

Key words: acceptance probability; compliance sampling; dual acceptance criteria; mixed sampling plan; order statistics; statistical methods.

A dual acceptance criterion based on the sample mean and an extreme statistic is used in many inspection procedures. Computation of the acceptance probability for such a dual criterion is investigated. An approximation and a lower bound to the acceptance probability are derived and are applicable to any continuous distribution. In addition, the connection between this dual criterion and hypothesis testing of scale and location parameters is studied. In the case of the exponential distribution the exact evaluation of the acceptance probability yields the power of the test.

Schmid, L. A. Mathematical analysis for radiometric calorimetry of a radiating sphere. *J. Res. Natl. Bur. Stand. (U.S.)* 87(6): 513-526; 1982 November-December.

Key words: calorimetry; Fourier equation; radiative cooling; specific heat; thermal diffusivity.

Equations are derived from which the temperature dependence of both the specific heat and the thermal diffusivity of a spherical sample of material can be calculated from observations of the time



dependence of the surface temperature and the time-rate of energy loss from the sample as it cools. The derivation takes into account the nonuniformity of the interior temperature field of the sample, and the resulting equations can be applied not only to radiative cooling, but also to any other cooling mechanism that does not violate the assumed spherical symmetry. The analysis excludes change of phase, but it does take thermal expansion into account. To permit the making of estimates necessary for the design of radiative cooling experiments, a universal temperature-time cooling curve is derived for the post-transient cooling regime of a radiating sphere of any size with arbitrary, but constant, thermal parameters.

## 5.2 PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 11, JANUARY-DECEMBER 1982

This journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The objective of the Journal is to provide critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques, whose aim is to assess the accuracy of available data in a given technical area, are also included. The principal source for the Journal is The National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements such as are normally reported in the primary research literature, nor for review articles of a descriptive or primarily theoretical nature.

Supplements to the Journal are published at irregular intervals and are not included in subscriptions to the Journal. They contain compilations which are too lengthy for a journal format.

### Volume 11, No. 1

Hill, P. G.; MacMillan, R. D. C.; Lee, V. A fundamental equation of state for heavy water. *J. Phys. Chem. Ref. Data* 11(1): 1-14; 1982.

Key words: enthalpy; equation of state; heavy water; Helmholtz function; *PVT*; specific heats; speed of sound; thermodynamic properties; vapor pressure.

A fundamental equation of state has been formulated for heavy water in the form  $\Psi = \Psi(p, T)$  in which  $\Psi$  = Helmholtz free energy,  $p$  = density,  $T$  = thermodynamic temperature. The complete range of single phase states in the range up to 100 MPa and 600°C is covered by a single equation which is fitted both to *PVT* values, for saturated and unsaturated states, and to enthalpy values for saturation states only. The equation is constrained to fit the critical point conditions determined by Blank. It represents all thermodynamic properties of  $D_2O$ , in the above range of states.

Rogers, P. S. Z.; Pitzer, K. S. Volumetric properties of aqueous sodium chloride solutions. *J. Phys. Chem. Ref. Data* 11(1): 15-81; 1982.

Key words: apparent molal volume; aqueous sodium chloride solutions; compressibility; density; equation of state; expansivity; Pitzer's equations; *PVT*; volume; volumetric properties.

Literature data for the volumetric properties of sodium chloride solutions to concentrations of 5.5 molal have been compiled and critically evaluated. A semi-empirical equation of the same type found to be effective in describing the thermal properties of NaCl solutions has been used to reproduce the volumetric data from 0°C to 300°C and 1 bar to 1000 bar. Tables of values are given for the specific volume, expansivity, and compressibility. Equations also are given for calculating the pressure dependence of the free energy, enthalpy, and heat capacity. These equations can be combined with a treatment of thermal properties to form a complete equation of state for sodium chloride solutions.

Pamdimukkala, K. M.; Rogers, D.; Skinner, G. B. Ideal gas thermodynamic properties of  $CH_3$ ,  $CD_3$ ,  $CD_4$ ,  $C_2D_2$ ,  $C_2D_4$ ,  $C_2D_6$ ,  $C_2H_6$ ,  $CH_3N_2CH_3$ , and  $CD_3N_2CD_3$ . *J. Phys. Chem. Ref. Data* 11(1): 83-99; 1982.

Key words: acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical.

Ideal gas thermodynamic properties,  $C_p^\circ$ ,  $S^\circ$ ,  $(G^\circ - H_{298}^\circ)/T$ ,  $H_f^\circ - H_{298}^\circ$ ,  $\Delta H_f^\circ$ ,  $\Delta G_f^\circ$  and  $\log K_p$  of formation for  $CH_3$ ,  $CD_3$ ,  $CD_4$ ,  $C_2D_2$ ,  $C_2D_4$ ,  $C_2D_6$ ,  $C_2H_6$ ,  $CH_3N_2CH_3$  and  $CD_3N_2CD_3$  in the temperature range 0-3000 K and at 1 atmosphere have been calculated by statistical thermodynamic methods employing spectroscopic and other molecular constants. The rigid rotor-harmonic oscillator model has been used. Estimated uncertainties in the thermodynamic properties due to uncertainties in the molecular properties and estimates of the effects of vibrational anharmonicities are also reported for each compound at three temperatures.

Kisiel, Z.; Millen, D. J. Peak absorption coefficients of microwave absorption lines of carbonyl sulphide. *J. Phys. Chem. Ref. Data* 11(1): 101-117; 1982.

Key words: absorption coefficients; carbonyl sulphide; intensities; microwave transitions; rotational transitions.

Peak absorption coefficients  $\alpha_{\max}$  for the  $J=1 \leftarrow 0$ ,  $J=2 \leftarrow 1$  and  $J=3 \leftarrow 2$  rotational transitions in carbonyl sulphide have been calculated for the different isotopic molecular species in natural abundance and in each case for a range of vibrational states. The results are tabulated for convenience both in order of values of  $\alpha_{\max}$  and in order of transition frequencies. Calculations have also been made, on a less extensive basis, for transitions from  $J=4 \leftarrow 3$  to  $J=25 \leftarrow 24$ , and peak absorption coefficients have been tabulated, in order of values of  $\alpha_{\max}$ , for each of these transitions. The tables provide a frequency coverage of approximately 10 to 300 GHz. Comparison with available experimental results shows satisfactory agreement.

Bishop, D. M.; Cheung, L. M. Vibrational contributions to molecular dipole polarizabilities. *J. Phys. Chem. Ref. Data* 11(1): 119-133; 1982.

Key words: atomic polarization; dipole polarizabilities; infrared intensities; molecular polarizabilities; vibrational polarizabilities.

An often overlooked, but nonetheless important, contribution to molecular dipole polarizabilities is that which comes from molecular vibration. This contribution, which was formerly called the atomic polarization, may be related to the intensities of the infrared-active bands. In this paper we have collected the best available intensity data for some hundred or so molecules and evaluated their vibrational polarizabilities. We have also given estimates of the probable errors of the final numbers.

Corliss, C.; Sugar, J. Energy levels of iron, Fe I through Fe XXVI. *J. Phys. Chem. Ref. Data* 11(1): 135-241; 1982.

Key words: atomic energy levels; atomic spectra; Fe; iron; iron energy levels.

This is a revision of the compilation of energy levels of iron for all ionization stages made in 1975 by Reader and Sugar. New material has since been provided for all but two of these ions. The present compilation includes electron configurations, energy levels, term designations, calculated leading percentages for most ions, experimental *g*-values, and ionization energies.

### Volume 11, No. 2

Lovas, F. J. Microwave spectra of molecules of astrophysical interest. XXI. Ethanol ( $C_2H_5OH$ ) and propionitrile ( $C_2H_5CN$ ). *J. Phys. Chem. Ref. Data* 11(2): 251-312; 1982.

Key words: ethanol; intensities; interstellar molecules; microwave spectra; molecular constants; propionitrile; radio astronomy; rotational spectrum.

The microwave spectra of ethanol ( $C_2H_5OH$ ) and propionitrile (ethyl cyanide,  $C_2H_5CN$ ) are critically reviewed and supplemented with spectral frequency calculations which include rotational and centrifugal distortion terms in the molecular Hamiltonian. The primary objective of this review is to provide the microwave transition frequencies applicable to molecular radio astronomy for the ground vibrational state of the most abundant isotopic forms, namely,  $^{12}C_2H_5^{16}OH$  and  $^{12}C_2H_5^{12}C^{14}N$ . Since the internal rotation and hyperfine splittings for these species have not been resolved in most of the reported laboratory studies and also not detected in the molecular clouds observed by radio astronomers, these splittings have been ignored in the present calculations. All measured rotational transitions are included, however, the predicted transition frequencies were limited to  $J=25$  for ethanol and  $J=30$  for propionitrile over the range of 1 GHz to 300 GHz. A complete summary of the laboratory studies of both species is included for all isotopic forms with references to all prior studies.



Gaur, U.; Wunderlich, B. **Heat capacity and other thermodynamic properties of linear macromolecules. V. Polystyrene.** *J. Phys. Chem. Ref. Data.* 11(2): 313-325; 1982.

**Key words:** atactic; crystal; crystallinity; density; enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene.

The heat capacity of polystyrene from 0 K to 600 K is reviewed on the basis of measurements on 29 samples reported in the literature. A set of recommended data for amorphous polystyrene is derived. The effect of tacticity on the heat capacity is also evaluated. Entropy and enthalpy functions are calculated. This paper is the fifth in a series of publications which will ultimately cover all heat capacity measurements on linear macromolecules.

Baulch, D. L.; Cox, R. A.; Crutzen, P. J.; Hampson, R. F., Jr.; Kerr, J. A.; Troe, J.; Watson, R. T. **Evaluated kinetic and photochemical data for atmospheric chemistry: Supplement I.** *J. Phys. Chem. Ref. Data.* 11(2): 327-496; 1982.

**Key words:** air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photo-absorption cross section; photochemistry; quantum yield; rate coefficient.

This paper updates and extends a previous critical evaluation of the kinetics and photochemistry of gas phase chemical reactions of neutral species involved in middle atmosphere chemistry (10-55 km altitude)[*J. Phys. Chem. Ref. Data* 9, 295 (1980)]. The work has been carried out by the authors under the auspices of the CODATA Task Group on Chemical Kinetics. Data sheets have been prepared for 228 thermal and photochemical reactions, containing summaries of the available experimental data with notes giving details of the experimental procedures. For each reaction a preferred value of the rate coefficient at 298 K is given together with a temperature dependence where possible. The selection of the preferred value is discussed, and estimates of the accuracies of the rate coefficients and temperature coefficients have been made for each reaction. The data sheets are intended to provide the basic physical chemical data needed as input for calculations which model atmospheric chemistry. A table summarizing the preferred rate data is provided, together with an appendix listing the available data on enthalpies of formation of the reactant and product species.

### Volume 11, No. 3

Janz, G. J.; Bansal, N. P. **Molten salts data: Diffusion coefficients in single and multi-component salt systems.** *J. Phys. Chem. Ref. Data.* 11(3): 505-693; 1982.

**Key words:** diffusion; diffusion coefficients; diffusion techniques; fused salts; molten salts; self-diffusion coefficients.

The property of diffusion is one of the basic properties of fluid systems. In molten salts, more than 700 studies have been reported to August, 1980, with more than 15 diffusion measurement techniques. A critical examination of these studies with a review of the techniques is presented. The results for more than 140 salt systems are reported in this communication as a series of data tables, with numerical values, value judgements, and literature citations. Silicates, slags, and oxide melts are excluded.

Chase, M. W., Jr.; Curnutt, J. L.; Downey, J. R., Jr.; McDonald, R. A.; Syverud, A. N.; Valenzuela, E. A. **JANAF Thermochemical Tables, 1982 Supplement.** *J. Phys. Chem. Ref. Data.* 11(3): 695-940; 1982.

**Key words:** critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables.

The thermodynamic tabulations previously published in four collections are extended by 227 new and revised tables. The JANAF Thermochemical Tables cover the thermodynamic properties over a wide temperature range with single phase tables for the crystal, liquid, and ideal gas state. In addition some multiphase tables are given. The properties given are heat capacity, entropy, Gibbs energy function, enthalpy, enthalpy of formation, Gibbs energy of formation, and the

logarithm of the equilibrium constant for formation of each compound from the elements in their standard reference states. Each tabulation lists all pertinent input data and contains a critical evaluation of the literature upon which these values are based. Literature references are given.

Smith, B. D.; Muthu, O.; Dewan, A.; Gierlach, M. **Critical evaluation of vapor-liquid equilibrium, heat of mixing, and volume change of mixing data. General procedures.** *J. Phys. Chem. Ref. Data.* 11(3): 941-951; 1982.

**Key words:** equations of state; heat of mixing; liquid density; mixtures; second virial coefficients; vapor-liquid equilibrium; vapor pressure; volume change of mixing.

This paper is the first in a series of reports on the critical evaluation of vapor-liquid equilibrium, heat of mixing, and volume change of mixing data for binary liquid mixtures of nonelectrolytes. The specific evaluation procedures for each property will be covered in subsequent articles. This paper describes the general procedures used to support the mixture evaluation work. The areas covered include the procedures used to cover the primary and secondary literature, the computer program libraries developed for pure compound and mixture data processing, the procedures used to evaluate and correlate the pure compound property data for use by the mixture programs, and the efforts made to make the best equation of state available to the vapor-liquid equilibrium data reduction programs. Improvements are suggested for the presentation of mixture data in the literature.

Leone, S. R. **Rate coefficients for vibrational energy transfer involving the hydrogen halides.** *J. Phys. Chem. Ref. Data.* 11(3): 953-996; 1982.

**Key words:** energy transfer; hydrogen halide; molecular relaxation; vibration.

A comprehensive compilation of rate coefficients for vibration-to-vibration (V-V) and vibration-to-translation (V-T) energy transfer processes involving hydrogen halide molecules is presented. The literature has been surveyed from 1966 to July 1981. Rate coefficients are grouped according to room temperature and low and high temperature results. Measured results are identified according to the type of process: V-V, V-T, or the sum of V-V and V-T processes. The method of measurement is identified along with the energy discrepancy, percent error, authors, and year of publication. The results are seen to be in excellent agreement when multiple measurements are available.

### Volume 11, No. 4

Merrill, L. **Behavior of the AB<sub>2</sub> type compounds at high pressures and high temperatures.** *J. Phys. Chem. Ref. Data.* 11(4): 1005-1064; 1982.

**Key words:** AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; experimental melting curves; high pressure; high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries.

Data on the polymorphic phase transformations of known compounds and new synthetic compounds of the type AB<sub>2</sub> have been compiled and evaluated. All available pressure studies have been included and referenced. Pressure-temperature phase diagrams showing first order solid-solid phase boundaries and/or melting curves showing the best fit to the experimental data are included. For some materials which can be produced only by chemical synthesis techniques at high pressures and high temperatures, reaction-product diagrams have been employed to estimate the region of thermodynamic stability. Crystallographic data of all the known phases of each material have been tabulated and evaluated. This review covers 168 compounds and 332 phases including the room temperature atmospheric pressure phase for each compound when it exists.

Gaur, U.; Lau, S.; Wunderlich, B. B.; Wunderlich, B. **Heat capacity and other thermodynamic properties of linear macromolecules. VI. Acrylic polymers.** *J. Phys. Chem. Ref. Data.* 11(4): 1065-1089; 1982.

**Key words:** enthalpy; entropy; glass transition; heat capacity;



linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid).

Heat capacity of poly(methyl methacrylate), polyacrylonitrile, poly(methyl acrylate), poly(ethyl acrylate), poly(n-butyl acrylate), poly(iso-butyl acrylate), poly(octadecyl acrylate), poly(methacrylic acid), poly(ethyl methacrylate), poly(n-butyl methacrylate), poly(iso-butyl methacrylate), poly(hexyl methacrylate), poly(dodecyl methacrylate), poly(octadecyl methacrylate) and polymethacrylamide is reviewed on the basis of measurements on 35 samples reported in the literature. A set of recommended data are derived for each acrylic polymer in the amorphous state. Enthalpy and entropy functions are calculated for poly(methyl methacrylate) and polyacrylonitrile. This is the sixth paper in a series of publications which will ultimately cover all heat capacity measurements on linear macromolecules.

Morin, L. R. M. Molecular form factors and photon coherent scattering cross sections of water. *J. Phys. Chem. Ref. Data.* 11(4): 1091-1098; 1982.

Key words: coherent scattering; cross section; form factor; Rayleigh scattering; tabulation; water; x rays.

Tabulations are presented of molecular form factors  $F(x)$ , for values of  $x = \sin(\theta/2)/\lambda$  from 0 to  $1.25 \text{ \AA}^{-1}$ , for liquid water at eight temperatures between  $4^\circ\text{C}$  and  $200^\circ\text{C}$  and for the free water molecule. For liquid water,  $x=0$  to  $1.25 \text{ \AA}^{-1}$ , the tabulated values are interpolated from experimental values of Narten and Levy (1971). For the free water molecule,  $x=0$  to  $1.25 \text{ \AA}^{-1}$ , the tabulated values are interpolated from calculated values of Blum (1971). For  $x=1.25$  to  $10^9 \text{ \AA}^{-1}$ , the independent atomic scattering hypothesis is assumed and the water molecular form factor  $F(x)$  is calculated from the hydrogen and oxygen atomic form factors given by Hubbell and Overbo (1979). Tables of coherent scattering cross sections, obtained by numerical integration of the Thomson formula, weighted by  $F^2(x)$ , are presented for liquid water at eight temperatures between  $4^\circ\text{C}$  and  $200^\circ\text{C}$  and for the free water molecule, for photon energies 5 keV to 1 MeV.

Smith, B. D.; Muthu, O.; Dewan, A.; Gierlach, M. Evaluation of binary  $PT_{xy}$  vapor-liquid equilibrium data for  $C_6$  hydrocarbons. Benzene+cyclohexane. *J. Phys. Chem. Ref. Data.* 11(4): 1099-1127; 1982.

Key words: activity coefficients; benzene; cyclohexane; evaluation procedures; excess Gibbs function; vapor-liquid equilibrium.

The methods used to evaluate subcritical binary  $PT_{xy}$  vapor-liquid equilibrium data are described. The evaluation results for the benzene+cyclohexane system are presented. The needs for new experimental data are defined.

Smith, B. D.; Muthu, O.; Dewan, A.; Gierlach, M. Evaluation of binary excess enthalpy data for  $C_6$  hydrocarbons. Benzene+cyclohexane. *J. Phys. Chem. Ref. Data.* 11(4): 1129-1151; 1982.

Key words: benzene; cyclohexane; evaluation procedures; excess enthalpy; heat of mixing.

The methods used to evaluate excess enthalpy data are described. The evaluation results for the benzene+cyclohexane system are presented. The needs for new experimental data are defined.

Smith, B. D.; Muthu, O.; Dewan, A.; Gierlach, M. Evaluation of binary excess volume data for  $C_6$  hydrocarbons. Benzene+cyclohexane. *J. Phys. Chem. Ref. Data.* 11(4): 1153-1171; 1982.

Key words: benzene; cyclohexane; evaluation procedures; excess volume; volume change of mixing.

The methods used to evaluate excess volume data are described. The evaluation results for the benzene+cyclohexane system are presented. The needs for new experimental data are defined.

## Supplements

Younglove, B. A. Thermophysical properties of fluids. I. Argon, ethylene, parahydrogen, nitrogen, nitrogen trifluoride, and oxygen. *J. Phys. Chem. Ref. Data.* 11(Suppl. 1): 354 pp.; 1982.

Key words: argon; critically evaluated data; density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties.

The thermophysical properties of argon, ethylene, parahydrogen, nitrogen, nitrogen trifluoride and oxygen are presented. Properties are given in tables and a standard set of equations is described. The tables list pressure, density, temperature, internal energy, enthalpy, entropy, heat capacity at constant volume, heat capacity at constant pressure, and sound velocity. Also included are viscosity, thermal conductivity, and dielectric constant, for some of the fluids. The equation and related properties of this report represent a compilation from the cooperative efforts of two research groups: the NBS Thermophysical Properties Division and the Center for Applied Thermodynamics Studies of the University of Idaho.

Wagman, D. D.; Evans, W. H.; Parker, V. B.; Schumm, R. H.; Halow, I.; Bailey, S. M.; Churney, K. L.; Nuttall, R. L. The NBS tables of chemical thermodynamic properties. *J. Phys. Chem. Ref. Data.* 11(Suppl. 2): 394 pp.; 1982.

Key words: chemical thermodynamics; enthalpy; entropy; evaluated data; Gibbs energy; inorganic chemistry; thermochemistry.

Recommended values are provided for chemical thermodynamic properties of inorganic substances and for organic substances usually containing only one or two carbon atoms. Where available, values are given for the enthalpy of formation, Gibbs energy of formation, entropy, and heat capacity at 298.15 K ( $25^\circ\text{C}$ ), the enthalpy difference between 298.15 and 0 K and the enthalpy of formation at 0 K. All values are given in SI units and are for a standard state pressure of 100 000 pascal. This volume is a new collective edition of "Selected Values of Chemical Thermodynamic Properties," which was issued serially as National Bureau of Standard Technical Notes 270-1 (1965) to 270-8 (1981). Values are given for properties of gaseous, liquid, and crystalline substances, for solutions in water, and for mixed aqueous and organic solutions. Values are not given for alloys or other solid solutions, fused salts, or for substances of undefined composition. Compounds of the transuranium elements are not included.

## 5.3 DIMENSIONS/NBS, ARTICLE TITLES ONLY

This magazine was discontinued with the October 1981 issue.



## 5.4 MONOGRAPHS

Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

**Monogr. 25, Section 19.** Morris, M. C.; McMurdie, H. F.; Evans, E. H.; Paretzkin, B.; Parker, H. S.; Pyrros, N. P.; Hubbard, C. R. **Standard x-ray diffraction powder patterns. Section 19—Data for 51 substances.** *Natl. Bur. Stand. (U.S.) Monogr. 25, Sec. 19*; 1982 December. 118 p. SN003-003-02462-7.

**Key words:** crystal structure; densities; lattice constants; powder patterns; reference intensities; standard; x-ray diffraction.

Standard x-ray powder diffraction patterns are presented for 51 substances. These patterns, useful for identification, were obtained by manual or automated diffractometer methods, or were calculated from published crystal structure data. The lattice constants from the experimental work were refined by least-squares methods, and reflections were assigned Miller indices consistent with space group extinctions. Relative intensities, calculated densities, literature references, and other relevant data are included.

**Monogr. 169.** Haynes, W. M.; Goodwin, R. D. **Thermophysical properties of normal butane from 135 to 700 K at pressures to 70 MPa.** *Natl. Bur. Stand. (U.S.) Monogr. 169*; 1982 April. 197 p. SN003-003-02406-6.

**Key words:** densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound.

Using a modified version of the nonanalytic equation of state, thermophysical properties of normal butane are derived from physical properties data and are tabulated at integral temperatures from 135 to 700 K along isobars at pressures to 70 MPa. These isobar tables, along with a table for the saturated liquid, give values for densities, compressibility factors, internal energies, enthalpies, entropies, heat

capacities, fugacities, sound velocities, dielectric constants, and isochore and isotherm derivatives. Equations, whose coefficients are determined from a least squares fit to selected experimental data, are also presented for vapor pressures, orthobaric liquid and vapor densities, ideal gas properties, second virial coefficients, dielectric constants, heats of vaporization, melting pressures, and orthobaric liquid specific heats, enthalpies, and entropies. Comparisons between experimental and calculated values for all properties considered here are reported in detail.

**Monogr. 170.** Goodwin, R. D.; Haynes, W. M. **Thermophysical properties of propane from 85 to 700 K at pressures to 70 MPa.** *Natl. Bur. Stand. (U.S.) Monogr. 170*; 1982 April. 249 p. SN003-003-02409-1.

**Key words:** densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound.

Thermophysical properties of propane are tabulated at integral temperatures over the entire range of fluid states from 85 to 700 K along isobars to 70 MPa by using a modified form of the nonanalytic equation of state. These tables, along with a table for the saturated liquid, include values for density, compressibility factor, internal energy, enthalpy, entropy, heat capacities, fugacity, sound velocity, dielectric constant, and isochore and isotherm derivatives. In addition to the equation of state, equations are presented for vapor pressures, orthobaric vapor and liquid densities, ideal gas properties, virial coefficients, dielectric constants, heats of vaporization, melting pressures, and orthobaric liquid specific heats, enthalpies, and entropies. Coefficients were determined by a least squares fit of selected experimental data, including several new sets of data not included in previous propane correlations. Comparisons between experimental and calculated values are given, including those for sound velocities, heat capacities, P- $\rho$ -T data, etc.

## 5.5 HANDBOOKS

Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

**H44.** Warnlof, O. K., ed. *Specifications, tolerances, and other technical requirements for weighing and measuring devices. Natl. Bur. Stand. (U.S.) Handb. 44*; 1982 September. 218 p. SN003-003-02429-5.

Key words: length-measuring devices; liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; user requirements; volume-measuring devices; weights.

Handbook 44 was first published in 1949, having been preceded by similar handbooks of various designations and in several forms, beginning in 1918. This 1983 edition was developed by the Committee on Specifications and Tolerances of the National Conference on Weights and Measures, with the assistance of the Office of Weights and Measures of the National Bureau of Standards. It includes amendments adopted by the 67th National Conference on Weights and Measures during its annual meeting in 1982. Handbook 44 is published in its entirety each year following the annual meeting of the National Conference on Weights and Measures.

**H130, 1983 Edition.** Brickenkamp, C., ed. *Model State Laws and Regulations. Natl. Bur. Stand. (U.S.) Handb. 130, 1983 Edition*; 1982 October. 102 p. SN003-003-02438-4.

Key words: basic weights and measures law; method of sale of commodities; open dating; packaging and labeling; registration of servicepersons; unit pricing; Weighmaster Law.

This Handbook compiles the latest Model State Laws and Regulations adopted by the National Conference on Weights and Measures (NCWM). The compilation itself was approved by the NCWM in 1979, and this edition includes amendments adopted at the annual meeting in 1982. The NCWM in 1981 decided to date the editions of Handbook 44 by the year in which substantive changes to

the Handbook become effective. Therefore, changes adopted by the NCWM in July 1981 were printed in the 1982 edition of H-44 (the effective date of changes was January 1, 1982). In order to avoid confusion, the date of this and of subsequent editions of Handbook 130 will also be the year following NCWM action. Therefore, this edition of Model State Laws and Regulations is dated the 1983 edition.

**H138.** Padikal, T. N.; Fivozinsky, S. P., eds. *Medical Physics Data Book. Natl. Bur. Stand. (U.S.) Handb. 138*; 1982 March. 127 p. SN003-003-02391-4.

Key words: data handbook; diagnostic radiology; general physics; medical physics; nonionizing radiation; nuclear medicine; radiation therapy.

The Medical Physics Data Book is a collection of physical and chemical data useful in medical physics. The information has been extracted from other published sources. The handbook is divided into five sections: General Physics, Nuclear Medicine, Diagnostic Radiology, Radiation Therapy, and Non-ionizing Radiation. Carried out by the Medical Physics Data Group of the American Association of Physicists in Medicine, this compilation is meant to serve as a handy reference to the numerical data needed by the practicing medical physicist.

**H140.** Hanson, A. G.; Bloom, L. R.; Cherin, A. H.; Day, G. W.; Gallawa, R. L.; Gray, E. M.; Kao, C.; Kapron, F. P.; Kawasaki, B. S.; Reitz, P.; Young, M. *Optical waveguide communications glossary. Natl. Bur. Stand. (U.S.) Handb. 140*; 1982 January. 33 p. Available from: NTIS; PB 82-166257.

Key words: fiber optics; optical communications; optical waveguides.

This is a technical dictionary containing approximately 450 entries relating to optical fiber waveguide communications.



## 5.6 SPECIAL PUBLICATIONS

Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

**SP250, 1982 Edition.** Kieffer, L. J., ed. **Calibration and related measurement services of the National Bureau of Standards—1982 Edition.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 250, 1982 Edition*; 1982 October. 114 p. SN003-003-02446-5.

**Key words:** calibration; measurement assurance; measurement services; standards; traceability.

This publication provides descriptions of the currently available NBS calibration services, special test services, and measurement assurance programs. In addition, each section describing specific services contains references to additional publications giving more detail about the measurement techniques and procedures used. This revised edition reflects the services available as of the first quarter of 1982. NBS Special Publication 250 was last issued in 1980. The Appendix to SP250 is reissued every 6 months (April and October). It lists current prices for the services described in this publication and the NBS points of contact (addresses and phone numbers) from whom additional information can be obtained.

**SP260-74.** Marinenko, R. B. **Standard reference materials: Preparation and characterization of K-411 and K-412 mineral glasses for microanalysis:** SRM 470. *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-74*; 1982 April. 25 p. SN003-003-02395-7.

**Key words:** chemical analysis; digital periodic integrator; electron probe microanalysis; glass standards; homogeneity testing; microhomogeneity; mineral glasses; standard reference material.

The two mineral glasses in SRM 470, K-411 and K-412, were quantitatively analyzed for major constituents. The results of wet chemical analyses from two independent laboratories were in excellent agreement; therefore, these results were used for certification. Quantitative electron probe microanalysis also agrees favorably with the certified compositions. Specimens were evaluated for micro- and macrohomogeneity with the electron microprobe by using random sampling and periodic integrator homogeneity trace techniques. Statistical analyses as well as the homogeneity traces showed no obvious composition fluctuations either within each specimen or among different specimens. These glasses are therefore excellent standards for microanalytical techniques. They are primarily composed of silicon, iron, magnesium, calcium, and aluminum oxides, none of which is present in less than 9 weight percent nor more than 55 weight percent.

**SP260-75.** Weidner, V. R.; Hsia, J. J. **Standard reference materials: Preparation and calibration of first-surface aluminum mirror specular reflectance standards.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-75*; 1982 May. 26 p. SN003-003-02399-0.

**Key words:** absolute reflectance; aluminum mirrors; first-surface mirrors; specular reflectance; specular standards; standard mirrors; standard reference material.

A number of first-surface aluminum mirrors of high optical quality have been prepared and calibrated for use as specular reflectance standards over the wavelength range 250 to 2500 nm. The specular reflectance calibrations are provided at 25 selected wavelengths, including the laser wavelengths of 632.8 nm and 1060 nm. These mirrors are approximately 50 mm in diameter. The aluminum coating is vacuum deposited on a 9.5 mm thick glass substrate. The mirrors were aged for two years before calibrating. The absolute reflectances of these mirrors were determined by direct comparison to the master first-surface aluminum mirror. The calibration of the master mirror was accomplished by extensive measurements, using the NBS Reference Specular Reflectometer-Spectrophotometer. The absolute techniques for measuring specular reflectance by means of this instrument include analysis of the reflectance of the mirror as a function of wavelength, polarization, and angle of incidence. The measurements obtained through these techniques are uncertain by  $\pm 0.2\%$ . The calibration of the Standard Reference Material mirrors was accomplished by direct comparison with the master mirror, using a commercial spectrophotometer. The uncertainty in the values of

reflectance obtained by this comparative method of calibration is  $\pm 0.5\%$ .

**SP260-76.** Hicho, G. E.; Eaton, E. E. **Standard reference materials: A standard reference material containing nominally five percent austenite (SRM 485a).** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-76*; 1982 August. 25 p. SN003-003-02433-3.

**Key words:** austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence.

This Standard Reference Material, SRM 485a, is a renewal of SRM 485, and is intended for the calibration of x-ray diffraction equipment used in determining the amount of retained austenite in hardened steels. The SRM was produced using powder metallurgical techniques and involved blending 5 percent by weight AISI type 310 stainless steel powder (austenitic) with AISI type 430 stainless steel powder (ferritic). From this blend, 216 compacts were produced and subsequently examined for nickel content by x-ray fluorescence spectrometry. A calibration curve was established using 13 compacts randomly selected from the population of 216. The curve relates the weight percent nickel from x-ray fluorescence measurements to the volume percentage austenite as determined by quantitative microscopy measurements of area percent. The curve was then used to assign the certified values to the remaining compacts. This SRM may be used as an x-ray diffraction standard for retained austenite or in very special cases as an x-ray fluorescence standard for nickel content.

**SP260-77.** Furukawa, G. T.; Riddle, J. L.; Bigge, W. R.; Pfeiffer, E. R. **Standard reference materials: Application of some metal SRM's as thermometric fixed points.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-77*; 1982 August. 140 p. SN003-003-02434-1.

**Key words:** aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point.

Equipment and procedures are described for the realization of liquid-solid phase equilibrium states of some pure metals as thermometric fixed points for platinum resistance thermometry. The design and techniques for assembling fixed-point cells using Standard Reference Materials (SRM) 740 (zinc), 43h (zinc), 42g (tin), 741 (tin), 44f (aluminum), 746 (cadmium), and 743 (mercury) are given and the results of the measurements using the purer of these metal SRM's are analyzed and evaluated. The reproducibility of temperature measurements with these metal SRM's is shown to be about  $\pm 0.1$  mK.

**SP260-78.** Hicho, G. E.; Eaton, E. E. **Standard reference materials: A standard reference material containing nominally thirty percent austenite (SRM 487).** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-78*; 1982 September. 25 p. SN003-003-02435-0.

**Key words:** austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence.

This Standard Reference Material, SRM 487, is intended for the calibration of x-ray diffraction equipment used in determining the amount of retained austenite in hardened steels. The SRM was produced using powder metallurgical techniques and involved blending 30 percent by weight AISI type 310 stainless steel powder (austenitic) with AISI type 430 stainless steel powder (ferritic). From this blend, 233 compacts were produced and subsequently examined for nickel content by x-ray fluorescence spectrometry. A calibration curve was established using 19 compacts randomly selected from the population of 233. The curve relates the weight percent nickel from x-ray fluorescence measurements to the volume percentage austenite as determined by quantitative microscopy measurements of area percent. The curve was then used to assign the certified values to the remaining compacts. This SRM may be used as an x-ray diffraction standard for retained austenite or in very special cases as an x-ray fluorescence standard for nickel content.

**SP260-79.** Richmond, J. C.; Hsia, J. J.; Weidner, V. R.; Wilmering, D. B. **Standard reference materials: Second-surface mirror standards of**



spectral specular reflectance (SRM's 2023, 2024, 2025). *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-79*; 1982 October. 41 p. SN003-003-02447-3.

Key words: aluminum mirrors; directional specular reflectance; reflectance specular; reflectance standards; second surface mirrors; solar reflectance; specular spectral reflectance.

NBS was requested by the Department of Energy to prepare, calibrate and disseminate standards of spectral specular reflectance for use in calibrating reflectometers used to evaluate the solar specular reflectance of concentrating mirrors used in solar energy systems.

The mirror chosen was a second-surface mirror of vacuum-deposited aluminum on optically polished vitreous quartz backed up with a second plate of ground and polished vitreous quartz cemented to the back of the mirror. Standards were prepared in two sizes, 51×51 mm, and 25×101 mm.

The cost of developing and calibrating the standards was included in a contract issued by the Solar Energy Research Institute of Golden, Colorado, which is financed by the Department of Energy.

SP260-80. Schaffer, R.; Mandel, J.; Sun, T.; Cohen, A.; Hertz, H. S.; Neese, J. W. Standard reference materials: Evaluation by an ID/MS method of the AACC reference method for serum glucose. *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-80*; 1982 October. 55 p. SN003-003-02443-1.

Key words: clinical analysis; glucose in serum; glucose reference method; isotope dilution/mass spectrometry; reference method; statistical analysis.

In conjunction with a study group of the Committee on Standards of the American Association for Clinical Chemistry working to establish a reference method for glucose in serum, the authors from NBS developed an isotope dilution/mass spectrometric method (ID/MS) for providing essentially bias-free, precise serum glucose analyses. This method, which is too elaborate for clinical laboratory use as a reference method, involves addition of a known amount of D-glucose- $U^{13}C$  to a serum sample, conversion of the labeled and unlabeled glucose in the sample into 1,2:5,6-di-O-isopropylidene-D-glucose (DAG), and measurement of the ratio of labeled to unlabeled DAG as the corresponding  $(M+1)^+$  ions, by isobutane-chemical ionization mass spectrometry. Five serum pools having glucose concentrations ranging from 0.4 to 3.0 g/L were analyzed. The relative standard deviation among single measurements made on different samples of the same pool was found to range from 0.34 to 0.46 percent for four of the pools, and was 0.79 percent for the pool with the highest glucose concentration. Pool concentrations were also determined from the same DAG samples using electron impact mass spectrometry and monitoring the ratios of corresponding  $(M-15)^+$  ions, and the results were similar. There was no evidence of bias.

These serum pools were used by the study group for a statistically controlled interlaboratory test to evaluate a hexokinase/glucose-6-phosphate dehydrogenase method as the reference method for glucose. Investigators at the Centers for Disease Control (Atlanta) had found that method the most appropriate of the several clinical glucose methods that were studied as possible reference methods. [J. W. Neese *et al.* HEW Publication No. (CDC) 77-8330]. Statistical analysis of the multilaboratory results showed that the relative standard deviations among single measurements made in different laboratories decreased as glucose concentrations increased. With manual pipetting used for performing the candidate reference method, the relative standard deviation ranged from 4.4 to 1.2 percent; with semi-automated pipetting, the range was 2.8 to 0.8 percent. Compared to the ID/MS results, the mean values found by the candidate reference method were about 1 percent higher at the 0.4 g/L level and changed linearly to about 2 percent lower at the 3.0 g/L level. We conclude that the candidate reference method fulfilled our prechosen criterion for acceptance as a reference method for serum glucose.

SP305. Supplement 13. Burris, B. L.; Morehouse, R. J., eds. Publications of the National Bureau of Standards 1981 Catalog. A compilation of abstracts and key word and author indexes. *Natl. Bur. Stand. (U.S.) Spec. Publ. 305, Suppl. 13*; 1982 May. 474 p. SN003-003-02400-7.

Key words: abstracts, NBS publications; key words; publications, NBS.

The 13th Supplement to Special Publication 305 lists the 1981

papers which reflect the results of the National Bureau of Standards programs. Also included are those NBS papers published prior to 1981 but not reported in previous supplements of SP305. In addition to bibliographic data, key words, and abstracts for each publication and/or paper, the catalog provides an author and key word index.

SP400-70. Harman, G. G. Semiconductor measurement technology: The use of acoustic emission to determine the integrity of large Kovar glass-sealed microelectronic packages. *Natl. Bur. Stand. (U.S.) Spec. Publ. 400-70*; 1982 May. 80 p. Available from: NTIS; PB 82-234485.

Key words: acoustic emission; hermeticity; hybrid microelectronics; hybrid packages; microelectronic packaging; thermal shock; vibration.

The general objective of this research was to develop tests to determine the integrity of large hybrid packages under various thermal and mechanical stresses that may be encountered during assembly, during installation in systems, or in operation. Several measurement techniques were investigated, but emphasis was placed on acoustic-emission test procedures. The accomplishments were: (1) The effects of avionics environmental vibration on the seals of hybrid packages mounted on printed-circuit (PC) boards were determined. A major conclusion of this section was that lead fatigue failure occurs before seal damage on packages from high quality lots. (2) A small acoustic-emission detector was developed that is sensitive to surface waves, but relatively insensitive to vibration induced cable noise. (3) A high-temperature (125°C) open-package helium leak test method was successfully developed to observe marginal seal damage. (4) An acoustic-emission test for inspection of hybrid packages during high-temperature thermal shock was developed. (5) A study of possible damage to seals during thermocompression and thermosonic bonding, during lead forming, and during other assembly operations was carried out. A general conclusion of this study is that the glass-metal seals in packages from known high quality lots are very reliable even when subjected to high stresses. However, the seals from packages "screened as good" from reject or poor quality lots are subject to hermetic failure under moderate stresses. There is little correlation between visual inspection failures of glass seals and their hermeticity.

SP400-71. Wilson, R. G.; Jamba, D. M. Semiconductor measurement technology: Differential capacitance-voltage profiling of Schottky barrier diodes for measuring implanted depth distributions in silicon. *Natl. Bur. Stand. (U.S.) Spec. Publ. 400-71*; 1982 February. 58 p. Available from: NTIS; PB 82-183575.

Key words: automatic C-V profiler analyses; carrier depth distributions; differential capacitance-voltage profiling; ion implantation; ranges of application and limitations; Schottky barrier diodes; SIMS and C-V profile comparisons.

This report discusses experimental and analytical aspects of differential capacitance-voltage profiling of ion-implanted carrier depth distributions using reverse-biased Schottky barrier diodes and the associated accuracies, experimental errors, and ranges of applicability.

SP400-72. Cohen, E. C.; Ruthberg, S., eds. Semiconductor measurement technology: NBS/RADC workshop moisture measurement technology for hermetic semiconductor devices, II. Proceedings of the NBS/RADC Workshop held at the National Bureau of Standards; 1980 November 5-7; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 400-72*; 1982 April. 302 p. SN003-003-02402-3.

Key words: analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; moisture generators; moisture sensors; quality control; reliability of semiconductor devices; semiconductor devices.

The Workshop, one of a series concerned with measurement problems in integrated circuit processing and assembly, served as a forum to examine the progress that has been made in the measurement and control of moisture in hermetically packaged semiconductor devices. While moisture-induced failure modes and mechanisms have been extensively documented, the lack of accurate and reliable measurement of the moisture content itself has been a major obstacle to meaningful efforts to limit and control this pervasive contaminant. Manuscripts are provided of 36 presentations which detail the progress that has been made in mass spectrometer measurements and



calibration of internal package moisture, in increased assurance with moisture sensors, in testing, and in package control. *These proceedings include the following papers (indented):*

**SP400-72; 1982 April. 3-7. Pernicka, J. C.; Raby, B. A. The paradox of moisture measurement a modern tetralogy.**

**Key words:** algorithms; calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; software; sorption; water.

This tetralogy is an exposition of four subjects which influence the mass spectrometric determination of water in semiconductor packages. These concerns are: calibration procedures; the automation of instrumentation and data processing; the perturbation of gas flow during sample transfer; and the detrimental effects of oxygen's chemical reactivity. The discussions also lead to a consideration of several paradoxes which entangle moisture measurement.

**SP400-72; 1982 April. 8-14. Perkins, K. L. Three volume calibration valve—Calibration and operation procedure for the carousel mass spectrometer system.**

**Key words:** mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; moisture measurement; three volume calibration valve; three volume calibrator; water-vapor measurement.

Results obtained using the three volume calibration valve (TVCV) with a carousel quadrupole mass spectrometer system show that it is an indispensable addition. Use of the TVCV revealed two important facts. One was that consistent system conditions must be established prior to each analysis to obtain reproducible water-vapor measurements. The procedure found suitable for this purpose was to precondition the system by analyzing a room air sample and then evacuating the sample chamber to  $2 \times 10^{-8}$  Torr. The other was that the water-vapor sensitivity factor is not constant, but varies with the sample volume and the water-vapor concentration. This means that to obtain accurate measurements, the system must be calibrated over a range of water-vapor concentrations for the volume of the package being analyzed. Since Rockwell's primary concern is hybrids, the system was calibrated using the largest volume of the TVCV. Samples containing 5000 PPM<sub>v</sub> were analyzed first, and the system sensitivity factor was adjusted to give a corresponding measured value. Samples containing approximately 1000, 5000, and 9000 PPM<sub>v</sub> were then analyzed and correction factors calculated. These results were plotted on semi-log paper in the form most convenient to the operator, i.e., Measured Water-Vapor Content versus Correction Factor.

**SP400-72; 1982 April. 15-18. Lowry, R. K. Gaseous compositions of hermetic package cavity ambients.**

**Key words:** gas analysis; gases in hermetic packages; hermetic IC packages; internal water vapor; mass spectroscopy; moisture measurement.

Mass spectrometric measurement of internal water vapor content also yields data on other volatiles in the package cavity. Identities and concentrations of all the gases present can supply useful information for packaging technology improvements to produce cleaner and drier parts. This paper describes some of the relationships found between levels of moisture and associated levels of N<sub>2</sub>, O<sub>2</sub>, H<sub>2</sub>, CO<sub>2</sub>, and Ar in several different package styles.

**SP400-72; 1982 April. 19-31. Gale, R. J. Correlation between mass spectrometer and aluminum oxide sensor measurements of moisture in hermetic packages.**

**Key words:** humidity; mass spectrometry; moisture sensors; packaging; reliability; standard packages.

Correlation has been obtained between mass spectrometer measurements and aluminum oxide sensor (Mini-Mod-A, Panametrics, Inc., Waltham, MA 02154) measurements of the water vapor content of hermetic packages. Side-brazed,

multilayer ceramic packages were seam sealed in a controlled humidity glove box at moisture levels of 11,000, 6100, 5100, and 2600 ppmV in nitrogen. Aluminum oxide sensors which were calibrated using an optical dew point hygrometer were sealed inside some of the packages at each moisture level, providing monitors for each lot. The preparation of the packages and calibration of the sensors is described in a separate paper by M. L. White and R. E. Sammons. The calibration of the mass spectrometer was accomplished using two independent methods to determine the sensitivity factor for water vapor: 1) the use of packages containing 6100 ppmV of water vapor in nitrogen (as measured by the aluminum oxide moisture sensors) as standards; and 2) the use of bursts of room air with a dew point hygrometer determination of the actual moisture content of the air. Using either calibration technique, the mass spectrometer measurements were found to be within  $\pm 25\%$  of the aluminum oxide sensor measurements at each of the four moisture levels.

**SP400-72; 1982 April. 32-38. Moore, B. A. Moisture standards for mass spectrometers.**

**Key words:** certification; mass spectrometry; Method 1018; quantitative analysis; standards; water vapor.

The results of prior attempts at producing and distributing (via analytical round robins) standards are discussed with respect to sealing techniques, package materials, and screening procedures. The culmination of learning experiences associated with the manufacture of an acceptable standard is the TO-18 candidate that was used in the second phase of the program to certify analytical facilities as capable of performing accurate moisture analysis in accordance with Method 1018 (Internal Water-Vapor Content) of MIL-STD-883B. The results show correlation among test laboratories analyzing the TO-18 and strongly suggest these samples are good candidates for static moisture standards.

**SP400-72; 1982 April. 39-48. Moore, B. A. Method 1018.2 certification results.**

**Key words:** calibration; certification; mass spectrometry; method 1018.2; quantitative analysis; water vapor.

The presence of moisture within a microelectronic package can have a detrimental effect upon the reliability of the enclosed device. In order to screen these reliability hazards from military electronic, avionic, and armament systems, a military test method, 1018.2 (Internal Water-Vapor Content) was generated that detailed acceptable methods of water-vapor analysis. The most prevalent method was mass spectrometric quantitative analysis of integrated circuit package ambients. However, problems arose in developing a suitable "standard" for assurance of accurate moisture analysis in order to obtain correlation among various analytical facilities. The described program, a result of Government, electronic industry, and analytical laboratory efforts, resulted in the acceptance of several laboratories as certified to perform Method 1018.2 analysis. Details of the effort, as well as results, are presented and lead to the conclusions that (1) practical criteria were developed and met, (2) common calibration equipment aided the correlation between laboratories, and (3) dynamic and static standards gave correlative results.

**SP400-72; 1982 April. 49-63. White, M. L.; Sammons, R. E. A procedure for preparing hermetic packages with known moisture levels.**

**Key words:** dew point; hermetic packages; mass spectrometer; seam sealing; sensor chips; standards; water vapor.

Side-brazed, multi-layer ceramic packages containing known moisture levels have been prepared by hermetic sealing in a humidity controlled glove box. This control is achieved by saturating nitrogen with water vapor at slightly higher than room temperature and combining it in known ratios with dry nitrogen as the gas supply for the glove box. Metal lids are gold-tin alloy sealed on ceramic packages using a parallel seam sealer in the glove box. The concentration of water in the package after sealing is determined with commercial porous aluminum oxide sensor chips. These chips are individually calibrated subsequent to all measurements on the sealed package to account for



calibration shifts occurring during assembly heat cycles.

Continuous monitoring shows an increase in moisture level in the package immediately after sealing, followed by a gradual decrease over a 200-hour period at room temperature to a stable value within 20 percent of the controlled humidity at the time of sealing. Using this technique, it is possible to assemble packages at any desired humidity level, with or without in-situ moisture sensors.

**SP400-72; 1982 April. 64-75. Lowry, R. K. A surface conductivity moisture monitor for hermetic IC packages.**

**Key words:** gas analysis; hermetic IC packages; in-situ moisture monitor; internal water vapor; moisture measurement; surface conductivity moisture monitor.

An in-situ surface conductivity sensor for measuring water content of hermetic package cavity ambients is described. The sensor is a 50×95 mil chip whose surface consists of an interdigitated pattern of aluminum stripes on silicon dioxide. The chip is mounted and wire bonded as a test vehicle into the package configuration whose moisture content is to be determined. The hermetically sealed specimen package is cooled in a temperature bath with 50 V dc applied to the sensor. As moisture condenses onto the sensor surface, the leakage current of the metal pattern rises. The temperature value of the leakage current peak represents complete condensation of all available water vapor, and this is nomographically converted to ppmv water content.

Sensor performance is evaluated via correlation experiments with mass spectroscopy and volume-effect sensors. Use of the sensor to estimate levels of metal ions within the package cavity is also described.

A revised sensor design, now undergoing testing, is described. The revised sensor incorporates an on-board diode structure permitting accurate measurement of actual sensor surface temperature as the specimen package is cooled.

**SP400-72; 1982 April. 76-78. White, M. L.; Walcheski, A. F. Some observations on the response of dew point detection chips.**

**Key words:** contamination; dew point; hermetic packages; moisture; packaging; water vapor.

The response of a commercial dew point sensing chip has been found to be very sensitive to the treatment of the chip prior to sealing it in a hermetic package. Chips without any precleaning that were put into side brazed ceramic packages containing about 5000 ppm<sub>v</sub> water vapor [1] and solder sealed at a low temperature showed no response while monitoring direct current leakage down to -35°C, using either a spot cooling or a total package cooling technique. When the lid was removed from these packages and moisture condensed from room air by cooling the chip, or by breathing on the chip, the condensate was in the form of very small droplets. With this dropwise condensation, there is not a continuous film of water between the interdigitated electrodes that are used for sensing leakage. Thus, there is not a significant change in the surface leakage current.

**SP400-72; 1982 April. 79-89. Kovac, M. G. Cross correlation experiments on different types of sensors.**

**Key words:** aluminum oxide moisture sensor; moisture sensors; pn junction temperature sensor; surface conductivity sensor; time response of moisture sensors.

This paper describes experiments conducted to determine the correlation between the aluminum oxide sensor and the surface conductivity sensor. It is shown that the correlation exists if the onset of conduction (not the peak) is taken as the dew point in the case of the surface conductivity sensor. The "time response" of both types of sensors is described, and its effect on interpretation of results is outlined.

**SP400-72; 1982 April. 90-97. Hale, J. C.; Fong, V. Moisture sensors, mass spectrometry, and MIL standards.**

**Key words:** aluminum oxide sensors; Cerdip; Cerpak; leak detection; mass spectrometry; Method 1018; moisture sensors; surface conductivity sensors.

This paper describes a series of experiments, where two types of "in-situ" moisture sensor chips were studied, installing them in three ceramic glass-sealed package styles. Both vitreous and nonvitreous sealing glasses were used. The subsequent data were analyzed in terms of mass spectrometry results, and performed in accordance with MIL-STD-883B, Method 1018, Procedure 1. An aluminum oxide moisture sensor chip was found to offer a straightforward correlation. Due to difficulties encountered in the procedure of data acquisition, it was not possible to determine a similar correlation when using a surface conductivity-type moisture sensor chip. Nonetheless, the surface conductivity chip was found to be useful in terms of identifying wet packages and dry packages, even though quantification of moisture levels is difficult if not uncertain. The reasons for measurement ambiguities of the surface conductivity sensor as a system are discussed with projections for future work necessary. Each moisture measurement system is discussed in terms of its respective leak detection capability. A nonvitreous seal glass was found to cause relatively high failing moisture levels, while two vitreous sealing glasses were found to give dry packages.

**SP400-72; 1982 April. 98-104. Unger, B. A.; Bossard, P. R. Dew point moisture measurements.**

**Key words:** capacitance; cooling rate; dew point; leakage current.

Moisture measurements by the dew point technique have been reported by several investigators. Recording either the capacitance or leakage between interdigitated lines as a device is cooled results in a curve that rises steeply, peaks out, and falls rapidly as the temperature is lowered. Data showing the strong dependence of the dew point measurement on cool-down rate and temperature sensor positioning are presented. Data on the accuracy and sensitivity of the leakage current and capacitance technique using a laser machined sensor are presented.

**SP400-72; 1982 April. 105-109. Mucha, J. A.; Bossard, P. R. Water vapor measurements in integrated circuit packages using an infrared diode laser.**

**Key words:** derivative spectroscopy; diode laser; humidity; infrared; microcircuits; moisture; reliability; water vapor.

The need for reliable and accurate measurements of water vapor in circuit packages for process control and reliability assurance is well established. A new technique for measuring the water content in hermetic packages has been developed. These measurements have been made on sealed packages that have been ruptured so that the internal atmosphere is exposed to a test cell. The time-dependent derivative spectra obtained from the test cell using a tunable infrared laser operating in the 6-μm region are used to determine the water vapor content in a manner that is independent of the cell walls. The experimental technique and the calibration procedure that eliminates the effect of the test cell walls on the results of the measurements are presented. Detection limits of 1000 ppm from packages with a volume of 40 μl have been achieved.

**SP400-72; 1982 April. 110-112. Macko, R. F. A recent evaluation of Al<sub>2</sub>O<sub>3</sub> moisture sensors in metal hybrid packages.**

**Key words:** hybrids; moisture measurement; oxide moisture sensors.

Aluminum-oxide moisture sensors were installed in over 125 hybrid packages and the interior moisture concentration was measured as a function of assembly and processing procedures. Calibration of the sensors was made before and after processing. The time residual moisture content could only be determined after extended baking at temperatures greater than 1000°C. The sensors were found to be effective in the resolution of problems in packaging and in process variations.

**SP400-72; 1982 April. 113-116. Siddiqui, S. H. Moisture monitoring and control during assembly of LSI circuits via in-situ moisture sensors.**



**Key words:** aluminum oxide; Cerdip packages; IC assembly; in-situ moisture sensors; LSI circuits; mass spectrometry; on-going monitoring activity; package-sealing environment.

Aluminum oxide based in-situ moisture sensors have been successfully used for on-going monitoring of moisture in package sealing environment during the assembly of LSI circuits. After establishing the initial correlation between the mass spectrometry and in-situ moisture sensor data, the on-going moisture monitoring via moisture sensor provided a relatively simple, quick, inexpensive, and convenient means for getting information regarding moisture contents in a package-sealing environment. The details of moisture-monitoring activities at two seal plants are described and the effectiveness of in-situ moisture sensors in providing us with information regarding actual and potential problems pertaining to moisture contents in the package-sealing environment are discussed.

**SP400-72;** 1982 April. 117-125. Poate, E. W. **Moisture failures in hybrids.**

**Key words:** adsorption; corrosion; dew point; failure modes; hybrid manufacturing; moisture sources.

Moisture-related failure modes are prevalent through the industry, accounting for approximately 25 percent of all hybrid rework. However, even today these failure modes are commonly ignored or misunderstood.

A brief overview of some of the most common sources of moisture found in hybrids and some of the most common moisture-induced failure modes are presented. A synopsis of experiments performed in a production facility is included.

**SP400-72;** 1982 April. 126-127. Thomas, R. W. **Test method 1018.2—A progress report.**

**Key words:** analytical laboratories; correlation; microcircuits; MIL-STD-8833; moisture measurement; moisture standards.

As a result of a three year program coordinated by the Joint Electron Device Engineering Council, a decision has been made by the Defense Electronic Supply Center to implement Test Method 1018.2 of MIL-STD-883 on 2 February 1981 for JAN devices. Correlation experiments indicate that better than  $\pm 20\%$  transferability has been achieved between test laboratories on sample packages with known moisture content. It is recommended that the new Test Method should only be used as a pass or fail determination at 5000 or 6000 ppmv and for package volumes of .01-.85 cc. This recommendation is justified on the basis that correlation has not been established at other limits. Other moisture measurement techniques have been or are in process of being developed which offer alternatives to the mass spectrometry technique.

**SP400-72;** 1982 April. 129-148. Bailey, A. R. **Conceptual model of aluminum corrosion of an integrated circuit.**

**Key words:** corrosion of an IC; IC surface; localized corrosion; surface model.

A conceptual model of a real Integrated Circuit (IC) surface has been developed. The model is applied to the corrosion of aluminum and the localized chemistry of aluminum corrosion. All corrosion starts out as a localized attack at a defect site, or area of high stress. Once started, a micro-corrosion cell forms, and the corrosion rate is independent of surface conductance and applied voltage.

The model can be used to develop a method for reliable encapsulation of IC devices.

**SP400-72;** 1982 April. 149-164. Cvijanovich, G. B. **Conductivities and electrolytic properties of adsorbed layers of water.**

**Key words:** adsorbed water; electrical conductivity; nonlocal process; surface conductivity; surface phenomena.

A model of the mechanism responsible for failures of integrated circuit (IC) devices encapsulated or unencapsulated is discussed. The functioning of this model is based on the fundamental assumption that electrical conductivity is essentially a nonlocal process. This means that the motion of an ion is a

function of the field values met not only at the position of that ion, but also in the immediate neighborhood of it. This fact greatly modifies electrochemical properties in adsorbed layers and on surfaces exposed to electrochemical interactions. From the investigations presented in this paper, it follows that the testing techniques practiced in the selection of encapsulants, at the present time, should be modified. In addition, the above analysis of nonlocal interactions can be applied to other surface phenomena as well as to other types of bulk nongap conductivities.

**SP400-72;** 1982 April. 165-174. Kovac, M. G. **Microenvironments and accelerated testing.**

**Key words:** accelerated moisture testing; microenvironments; moisture related failures; temperature effects on surface water.

This paper describes some of the problems associated with accelerated testing of integrated circuits for moisture related failures. The key factor is found to be maximizing the residence time of moisture on the surface under all conditions of temperature cycling and biasing. Also discussed is a new microelectronic chamber for establishing microenvironments.

**SP400-72;** 1982 April. 175-177. Ebel, G. H. **Moisture failure mechanism.**

**Key words:** dew point; failure; hybrid microcircuit; moisture; nichrome resistors; semiconductor devices.

This paper reports on some observations that were made as a result of a failure analysis on complex hybrid microcircuits. It suggests that failure modes are different for various internal moisture level contents. In a range above 17,000 ppm semiconductors failed. From about 6000 ppm to 17,000 ppm nichrome resistors failed and below 1000 ppm of moisture no failures occurred. Probably the most significant result of the observations is that, if the moisture content of the parts that had semiconductor failures had not been measured, the failures would never have been classified as moisture related.

**SP400-72;** 1982 April. 178-183. Duffey, J. R. **Experiences in microcircuit moisture problems.**

**Key words:** humidity; hybrids; microcircuits; moisture; moisture sensors; reliability.

This paper contains information on two moisture related experiences. Moisture sensors were placed in dummy hybrids to measure moisture content. These hybrids were placed in a 125°C oven for 32 hours. The moisture sensors were monitored during high temperature storage and after withdrawal. The behavior observed was different than that previously observed by Kovac. The presence of a previously undetected leaker was evident by anomalous behavior of the moisture sensor. This was later confirmed by residual gas analysis. There appears to be no correlation between the moisture value given by the sensor and that obtained by the residual gas analysis. A high reliability thin film space hybrid that had been extensively reworked was subjected to 125°C burn-in for 2500 hours, being tested every 500 hours. After 1000 hours this hybrid developed a leak. At the end of testing the hybrid was found to contain 154,000 ppm<sub>v</sub> of water. The hybrid still passed all electrical tests and showed no visual signs of corrosion.

**SP400-72;** 1982 April. 184-200. Davy, J. G. **Thermodynamic and kinetic considerations of moisture sorption phenomena.**

**Key words:** absorption; adsorption; dew point; hygrometer; kinetics; microelectronic package; moisture; moisture level; relative humidity; sorption thermodynamics.

Moisture sorption phenomena are predominant effects in microelectronic packages, and intuition about processes occurring inside may not be valid. In particular, the concept of dew point can be misleading, and reporting moisture levels in terms of relative abundance (ppm<sub>v</sub>) can also be misleading. Instead, use of relative humidity and mass of water in a particular state per unit of package volume is recommended. Models of absorption and adsorption are presented and applied to



microelectronic packages to determine RH and mass as a function of temperature. The use of conductance/capacitance cells and alumina capacitors as in-situ moisture sensors is discussed with reference to sorption processes. Finally, the possibility of condensation at an RH of less than 100 percent is considered for two special cases—ionic impurities on the surface and fine cracks in the passivation layer.

**SP400-72; 1982 April. 201-211. Marderosian, A. D. The detection of cracks in ceramic packages by vapor condensation.**

**Key words:** ceramic crack detection; ceramic cracks; ceramic fissures; crack detection; fissure detection; fissures; vapor crack detection.

This paper details a novel approach to the detection of cracks in ceramic semiconductor packages. The technique is extremely fast and has been designed to be a cost effective method of performing crack detection for high volume production applications as well as for traditional failure analysis. The test does not require any special lighting nor any optical magnification. It is capable of detecting cracks as fine as one-tenth of a micron in width. Although developed for a specific situation, the test may be useful for a wide variety of other applications.

**SP400-72; 1982 April. 213-219. Shukla, R. K.; SinghDeo, J.; Sharma, N. K.; Blish, R. Moisture content of solder glasses.**

**Key words:** Cerdips; desorption; mass spectrometry; moisture evolution analysis; water sorption phenomenon.

Cavity moisture content in Cerdips is strongly affected by the moisture evolution from physically adsorbed, chemisorbed and bulk moisture and is further aggravated by oxidation of residual carbonaceous species in the glazed glass. At Intel, we have characterized these variables by using various moisture evolution measurement methods. RGA and MEA (Moisture Evolution Analysis) help in understanding the high temperature moisture evolution from solder glass while the Karl Fischer method helps in characterizing surface adsorbed water. We have thus shown that organic impurities burnout can lead to as much as 30 percent excess moisture evolution from the solder glasses, this contribution being vendor dependent. Using these data, we are optimizing the Cerdip manufacturing process to get dry Cerdips.

**SP400-72; 1982 April. 220-233. Lowry, R. K. Dry sealing glasses—A summary of research.**

**Key words:** Cerdip; integrated circuit packaging; internal water vapor; moisture evolution; package reliability; sealing glass.

Ceramic dual-in-line (Cerdip) packages utilizing low temperature (less than approximately 500°C) sealing glasses have been widely deployed for packaging integrated circuits, but simultaneously condemned for high reliability applications due to high moisture content in the sealed cavity. Chemical and physical properties of the sealing glasses determine the quantity of water vapor which will be present in the sealed package. Extensive testing has established that vitreous glasses, when properly processed, contribute substantially less water vapor to a package cavity than the devitrifying glasses originally used. Vacuum microbalance and scanning electron microscopic studies are reported for a family of vitreous sealing glasses to help define processing parameters designed to assure dry Cerdip packages.

**SP400-72; 1982 April. 234-238. Thomas, R. W. What's wrong with Cerdips?**

**Key words:** Cerdip; glass sealed; integrated circuit; packages; quality control; thermal shock.

Recent mechanical failures of Cerdip type packages during board assembly operations prompted a study to determine the sensitivity of Cerdip packages to thermal shock. The results confirmed the potential hazard of exposing Cerdips to even minimal thermal shock (135°C to 25°C). The primary reason for the field failure was traced back to improper solder dipping operations in which the package was submerged in the solder bath and then quickly cooled in water during flux removal. Some

of the packages treated in this manner failed incoming leak testing while in other cases the lids fell off during shipment. Although electrical failures traceable to loss of hermeticity have not been found, it was recommended that these mechanically damaged parts not be used in military systems.

**SP400-72; 1982 April. 239-245. Schuessler, P. Moisture impermeable polymers.**

**Key words:** diffusion; hydrophobic; moisture permeation; polymeric materials; solubility.

By the late 70's the microelectronic manufacturers had made significant gains in the area of packaging with polymeric materials. Unfortunately, several fleet and field incidents occurred which rapidly brought polymer seals and encapsulants into disfavor with the military. In 1979, the Navy funded an effort with IBM FSD to investigate if indeed a hydrophobic polymer could be commercially available. This report relates the progress made to date in the identification and testing of water "impermeable" polymers. The two primary contributors to moisture permeation, solubility, and diffusion are addressed; included are insights to how permeation may be reduced via molecular reconfigurations and atomic substitution, unfortunately not to the limits presently in effect for the non-polymeric seals.

**SP400-72; 1982 April. 247-257. Merrett, R. P. A method of assessing the surface conductivity of plastic encapsulated integrated circuits.**

**Key words:** integrated circuits; moisture reliability; plastic encapsulation; surface conductivity.

The moisture-induced surface conductivity of passivated ICs, in plastic packages, has been measured using a technique previously used for ICs in hermetic enclosures. The method involves measurement of the capacitance between two metallisation tracks, at frequencies of 100 and 1000 Hz. By comparing the capacitances obtained before and after storage of the packages for 24 hours in a saturated autoclave at 110°C, it is possible (i) to detect whether water permeating the plastic has formed a conducting film on the surface of the die, and (ii) to obtain an estimate of the surface conductivity. The technique thus offers the prospect of the rapid appraisal of two of the factors affecting the reliability of plastic-encapsulated ICs in humid environments.

**SP400-72; 1982 April. 258-270. Baron, H. C.; Moser, F. R.; Susko, J. Internal moisture measurement of IBM integrated circuit memory package.**

**Key words:** egress; ingress; integrated circuit package; moisture; monolayer buildup.

Moisture measurements on IBM Integrated circuit packages and package materials have been conducted with the aid of a DuPont moisture analyzer and a unique moisture extraction apparatus designed by Mr. John Susko of IBM. The data indicate the quantity of moisture reaching the interior of the package is many times greater than the amount one would estimate solely from the free volume vapor space and the solubility of water in the various package materials at equilibrium. A case is made to support the hypothesis that a significant water monolayer buildup occurs within such a package. The experimental data also indicate that moisture ingress and egress through the epoxy package backseal is initially quite rapid and suggest a significant water monolayer; buildup occurs with a few days.

**SP400-72; 1982 April. 271-274. Ebel, G. H.; De Cristofaro, R. A. A method of leak detection and location for conformally coated packages.**

**Key words:** hermeticity; hybrid; leak test; methanol; silicone coating; UV light.

During failure analysis of a hermetically sealed microelectronic package, one important step is to verify the package's hermeticity. Unfortunately, many defective field units have been conformally coated which, it will be shown, interferes with standard hermeticity tests. Internal and external coatings can



enter and seal a leak path, allowing the device to erroneously pass a standard (He bomb) leak test. One approach to this problem is to attempt to remove the coating. This is impractical for internal coatings, and complete removal of external coating is difficult to achieve in practice. Another approach is to use a different type of leak detection, which is less affected by the coatings, such as the use of dye penetrants.

**SP400-72;** 1982 April. 275-280. Wong, C. P.; Maurer, D. E. **Improved RTV silicone for IC encapsulant.**

**Key words:** encapsulant; integrated circuit; RTV; silicone.

There is a large body of evidence that indicates that ionic contaminants affect the electrical reliability performance of encapsulated devices. These contaminants are introduced into the system through three main sources: improper substrate cleaning, the encapsulant, and the environment. Our research herein reported adds further evidence that ionic contaminants do affect performance and that compounds such as crown ethers and cryptates significantly improve the electrical performance of encapsulated devices.

**SP400-72;** 1982 April. 281-288. Forant, P. R. **Leak testing electronic components.**

**Key words:** bombing; fine leak test; gross leak test; helium; hermeticity; tracer gas.

The making and testing of hermetic seals to prevent moisture of other contaminants from entering the device in the manufacture of sealed parts is the subject of this paper. It is intended that the emphasis will be on fine leak detection with some notes on the overall leak detection process.

In order to make the point of hermeticity testing, the various tests are to be covered in the order they should occur. First, subassembly testing, then fine leak testing, followed by gross leak testing. The test order is important to the validity of the tests.

Subassembly tests are made prior to sealing the packages so that glass-to-metal seals, feedthroughs, etc., are proven prior to assembly of the chip and closing the cover. This sorts out leakers before the value added makes rejection too costly.

Fine leak tests are to be made after the final assembly is complete. In some cases the parts can be sealed in a helium rich atmosphere. The usual method involves pressurizing the parts in a helium atmosphere. The time of bombing and elapsed time of test for leak rates of varying sizes will be discussed.

Gross leak testing can be conducted in a number of ways. It is desirable to select a method that will give the desired results with reliability and with the least possibility of product damage.

**SP400-73.** Ruthberg, S. **Semiconductor measurement technology: Graphical solution for the helium leak detector and radioisotope methods of hermetic test. Master graphs and instructions.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 400-73;* 1982 November. 34 p. SN003-003-02453-8.

**Key words:** back pressurization; electronic packages; hermetic test; leak testing.

A graphical procedure for solution of the molecular flow approximation for the back pressurization method of hermetic test makes use of a set of characteristic curves and a test line. The characteristic curves are appropriate for both the helium leak detector and the radioisotope methods of test, although the form of the test line differs between the two methods. Master graphs of the characteristic curves and test lines are now provided in a scale and format appropriate for producing suitable worksheets with a copier. Step-by-step instructions are given for their use in obtaining solutions for various examples relative to the test specifications in acceptance standards such as MIL-STD 883B, etc. One set of characteristics is provided specifically for the helium leak detector mode as expressed directly in terms of air leak rate; a second set is provided specifically for the krypton-85 radioisotope mode also in terms of air leak rate; and a third set is retained in the original form for use with any tracer gas.

**SP400-74.** Jerke, J. M.; Croarkin, M. C.; Varner, R. N. **Semiconductor measurement technology: Interlaboratory study on linewidth measurements for antireflective chromium photomasks.** *Natl. Bur.*

*Stand. (U.S.) Spec. Publ. 400-74;* 1982 November. 191 p. SN003-003-02458-9.

**Key words:** dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests.

Optical microscopes fitted with a micrometer attachment are commonly used to measure small linewidths and other critical dimensions on integrated-circuit (IC) photomasks. In the absence of calibrated linewidth standards, users have experienced systematic measurement errors much larger than required manufacturing tolerances. As IC linewidths approach 1  $\mu\text{m}$  with a 10 percent tolerance, the need for calibration standards and improved measurement procedures becomes even more important.

This report discusses the results of an interlaboratory study to evaluate a National Bureau of Standards (NBS) prototype calibration standard for linewidth measurements on IC photomasks and procedures for adjusting and calibrating optical-microscope systems in the 0.5- to 12- $\mu\text{m}$  measurement range. Using procedures furnished by NBS, industrial participants measured line spacings and linewidths on NBS antireflective-chromium artifacts. A comparison of NBS linewidth values with participants' measurements showed that most differences were less than  $\pm 0.3 \mu\text{m}$ . A linewidth calibration significantly reduced systematic errors for most systems. Outliers in the data showed the need for measurement-control procedures. The standard deviation of the measurement process was  $\pm 0.1 \mu\text{m}$  or larger for about half of the systems. For some systems, there were significant day-to-day differences and operator differences.

The study showed that the NBS artifact and recommended procedures were adequate for calibrating an optical-microscope system which was in a state of statistical control. This study led to the issuance of NBS Standard Reference Material 474 (Optical Microscope Linewidth-Measurement Standard).

**SP446-6.** Raufaste, N.; Olmert, M. **Building technology project summaries 1981-1982.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 446-6;* 1982 September. 72 p. Available from: NTIS; PB 83-118646.

**Key words:** building research; building technology; codes; criteria; measurement methods; performance criteria; project summaries; technical bases.

The Center for Building Technology provides the technical and scientific bases for criteria and standards that improve the usefulness, safety and economy of buildings. The Center's activities support building technology programs of the Federal, State and local governments; assist design professions, building officials and the research community by providing design criteria that improve buildings; and assist manufacturers of building products by developing criteria for evaluating innovative building materials. This report summarizes the Center's projects for calendar years 1981-1982. It enables individuals to get a clear impression of CBT research activities.

**SP457-6.** Beavers, L., ed. **Building technology publications 1981—Supplement 6.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 457-6;* 1982 June. 94 p. SN003-003-02439-2.

**Key words:** abstracts; building technology; Center for Building Technology; key words; publications.

This report presents NBS' Center for Building Technology (CBT) publications for 1981. It is the sixth supplement to NBS Special Publication 457, *Building Technology Publications*, and lists CBT reports issued during January 1-December 31, 1981. It includes titles and abstracts of each CBT publication and those papers published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

This document is divided into three main sections. The first, *Titles and Abstracts*, provides the report title, author(s), date of publication, selected key words, and an abstract of each NBS publication and each paper published in an outside source. The *Author Index* cites CBT authors and their publication number which is listed in this supplement. The *Key Word Index* is a subject index, listing word summaries of the building research topics for each publication and paper. By selecting a main word or subject, the user is able to locate



reports of interest through these subject-related words.

**SP489, Supplement 1.** Nimmo, M. H.; Reznick, B., eds. **Abstracted reports and articles of the HUD Modular Integrated Utility Systems (MIUS) Program.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 489, Suppl. 1*; 1982 August. 120 p. SN003-003-02416-3.

**Key words:** abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; utility systems.

This document provides an additional listing of reports and articles relating to the HUD-MIUS Program. Reports published and selected since the issuance of NBS SP-489 are listed. Also included, for the sake of completeness, are some earlier reports which had not been included in the original NBS SP-489. Both NBS SP-489 and this document are required for full coverage. The entry for each report contains an abstract and other pertinent information, including procurement sources and procedures. Reports are grouped by four general subject categories: Program/Concept Description; Systems Analysis; Technology Evaluation; and Hardware Evaluation & Demonstration. The reports are further classified into three publication/availability categories: government publications (Published Reports); non-government publications and articles (Outside Publications); and "informal" reports and data (Open-File Reports). An overall subject index has been included which covers both NBS SP-489 and this document.

**SP500-85.** Shaw, J. K.; Katzke, S. W. **Computer science & technology: Executive guide to ADP contingency planning.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-85*; 1982 January. 16 p. Available from: NTIS; PB 82-165226.

**Key words:** ADP security; backup operations; computer security; contingency planning; emergency response; Federal Information Processing Standards Publication; recovery actions.

This document provides, in the form of questions and answers, the background and basic essential information required to understand the developmental process for Automatic Data Processing (ADP) contingency plans. The primary intended audience is executives and managers who depend on ADP resources and services, yet may not be directly responsible for the daily management or supervision of data processing activities or facilities. The publication should also be especially beneficial to individuals responsible for ensuring compliance with Office of Management and Budget Circular A-71, Transmittal Memorandum Number 1, July 27, 1978.

**SP500-86.** Computer Corporation of America. **Computer science & technology: An architecture for database management standards.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-86*; 1982 January. 52 p. SN003-003-02383-3.

**Key words:** database; database function; database management system; data model; schema; standards; system architecture; system components.

This report describes the current status of an Institute for Computer Sciences and Technology project on architectures for Database Management Systems. An architectural framework for developing DBMS standards is presented. It addresses requirements of both the Federal data processing community and the DBMS vendor community. The architecture groups DBMS functions into both internal and external components and proposes for these components a family structure that supports the integration of DBMS standards for multiple data models.

**SP500-87.** Neumann, A. J. **Computer science & technology: Management guide for software documentation.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-87*; 1982 January. 44 p. SN003-003-02384-1.

**Key words:** documentation; guidelines; life-cycle; software; specifications; standards.

This guide is to assist managers in the establishment of policies and procedures for effective preparation, distribution, control, and maintenance of documentation which will aid in re-use, transfer, conversion, correction and enhancement of computer programs. Such documentation, together with the computer programs themselves,

will provide software product packages which can be transferred and used by people other than the originators of the programs. "Software" and "documentation" are defined, some documentation problems are discussed, and policies, procedures, and applicable standards are outlined. Appendices provide checklists in support of documentation policies and procedures, and references to relevant guidelines, standards, and the literature. A glossary of terms is included.

**SP500-88.** Houghton, R. C., Jr. **Computer science & technology: Software development tools.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-88*; 1982 March. 193 p. SN003-003-02389-2.

**Key words:** programming aids; software automation; software development; software engineering; software testing; software tools.

As a part of the program to provide information to Federal agencies on the availability, capabilities, limitations, and applications of software development tools, a database of information about existing tools was collected over a 3-year period. The purpose of this report is to present an analysis of the information contained in the database. Various categorizations of the tools are presented in classes listed by their characteristic features. The lists incorporate percentage summaries that are based on the total number of tools for which information is stored in the database. Trends found in the lists are analyzed and discussed. Abstracts of each tool are presented in an appendix.

**SP500-89.** Wegstein, J. H. **Computer science & technology: An automated fingerprint identification system.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-89*; 1982 February. 47 p. Available from: NTIS; PB 82-177296.

**Key words:** computerized-fingerprint-identification; identification; pattern recognition.

Procedures are described for automatically identifying fingerprints. Machine-read ridge-direction and minutiae data are utilized in registering and enhancing search or file minutiae data. The quality of the data is measured. A procedure is then described for utilizing this minutiae data in determining whether two fingerprint impressions were made by the same finger.

**SP500-90.** Skall, M. W. **Computer science & technology: Guide to contracting for software conversion services.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-90*; 1982 May. 67 p. SN003-003-02393-1.

**Key words:** acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; portability; program inventory; RFP; statement of work.

This guide is the first in a series of publications which will be issued by the National Bureau of Standards with respect to conversion of Federal agency ADP systems. The need for these publications was determined by a study conducted in 1980, consisting of interviews with commercial conversion experts and Federal Government agency personnel who have recently experienced conversions, as well as a search of the current literature. The results of that study are documented in NBS Special Publication 500-62, entitled *Conversion of Federal ADP Systems: A Tutorial*. The purpose of this guide is to educate the Federal manager in the benefits which can be gained by contracting for conversion services as well as to specify all the actions the agency must take to ensure a successful conversion contract. The guide concludes that a smooth conversion can be accomplished by thoroughly planning the contractor's activities and effectively communicating these plans to the contractor.

**SP500-91.** Hecht, H. **Computer science & technology: The introduction of software tools.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-91*; 1982 September. 41 p. SN003-003-02414-7.

**Key words:** computer environments; software; software engineering; software management; software quality; software tools; toolsmith.

From a survey of current tool usage it is concluded that the greatest obstacles to effective use of software tools are encountered in organizations employing fewer than 40 programmers, and the needs



of these environments are therefore emphasized. Specific needs for software tools in programming for management information systems and for scientific applications are discussed. Measures are described to overcome organizational obstacles to use of tools, to deal with problems arising from the tools, and to reduce the difficulties posed by existing computer installations.

Steps required for the successful introduction of tools are organized in two ways: by the function responsible for their accomplishment, and by the time schedule in which they must be completed. The detail work to be performed in each step is described.

**SP500-92.** Goldfine, A. H., ed. *Computer science & technology: Data Base Directions: Information Resource Management—Strategies and tools*. Proceedings of the Workshop of the National Bureau of Standards and the Association for Computing Machinery; 1980 October 20-22; Fort Lauderdale, FL. *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-92*; 1982 September. 174 p. SN003-003-02419-8.

Key words: database; database design; data dictionary system; data management; DBMS; information resource management.

This report constitutes the results of a three-day workshop on information resource management tools, held in Fort Lauderdale, Florida on October 20-22, 1980. The workshop was sponsored jointly by the Institute for Computer Sciences and Technology of the National Bureau of Standards (NBS) and the Association for Computing Machinery (ACM).

Patterned after the two previous Data Base Directions workshops, this workshop, *Data Base Directions: Information Resource Management—Strategies & Tools*, investigated how managers can evaluate, select, and effectively use information resource management tools, especially data dictionary systems. The approximately seventy workshop participants were organized into four working panels, which met to discuss Uses of the Data Dictionary System, IRM Policies and Controls, Logical Database Design, and Physical Database Design. *These proceedings include the following papers (indented):*

**SP500-92;** 1982 September. 7-15. **DATA: The raw material of a paper factory.**

**SP500-92;** 1982 September. 17-47. **Uses of the information resource dictionary system for IRM.**

**SP500-92;** 1982 September. 49-71. **IRM policies and controls.**

**SP500-92;** 1982 September. 74-140. **Logical database design.**

**SP500-92;** 1982 September. 141. **Physical database design.**

**SP500-93.** Powell, P. B., ed. *Computer science & technology: Software validation, verification, and testing technique and tool reference guide*. *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-93*; 1982 September. 138 p. SN003-003-02422-8.

Key words: automated software tools; dynamic analysis; formal analysis; software testing; software verification; static analysis; test coverage; validation; V,V&T techniques; V,V&T tools.

Thirty techniques and tools for validation, verification, and testing (V,V&T) are described. Each description includes the basic features of the technique or tool, the input, the output, an example, an assessment of the effectiveness and usability, applicability, an estimate of the learning time and training, an estimate of needed resources, and references.

**SP500-94.** Neumann, A. J., ed. *Computer science & technology: NBS FIPS software documentation*. Proceedings of a Workshop held at the National Bureau of Standards; 1982 March 3; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-94*; 1982 October. 294 p. SN003-003-02455-4.

Key words: documentation; FIPS; guidelines; program documentation; software documentation; standards.

These proceedings provide a record of papers and discussions presented at a workshop held on March 3, 1982, at the National Bureau of Standards. The meeting was sponsored by the NBS Institute for Computer Sciences and Technology. In addition to papers presented, the record also provides remarks by discussants and other participants. The workshop covered a variety of topics

pertaining to software documentation. Topical sessions included: case studies of and reports on application of existing standards, documentation for operation and maintenance, tools for improved documentation, proposal for new documentation standards, enhancing software sharing, improving human interfaces, and quality assurance of documentation. Sixty-three papers were presented in parallel sessions, and a summary session concluded the meeting; over 300 persons participated in the workshop. *These proceedings include the following papers (indented):*

**SP500-94;** 1982 October. 8-15. Maskewitz, B. F. **User experience and compatibility in documentation standards. A summary.**

Key words: documentation standards; software compatibility; user experience.

This paper reviews existing guidelines for documentation of scientific computer programs or data libraries and outlines the essential elements for facilitating exchange of the software. Selected case studies will be made in which accepted standards were followed from the programming stage through documentation, and an analysis of user experience.

**SP500-94;** 1982 October. 16-22. O'Korn, L. J. **Systems development methodology and documentation practices.**

Key words: development methodology; documentation process; software documentation.

The approach Chemical Abstracts Service (CAS) has taken to prepare and manage the full range of software documentation will be described. For each development stage this presentation will summarize the deliverable items of documentation, specific standards and procedures guiding the documentation process, and specific tools supporting the preparation and management of documentation.

**SP500-94;** 1982 October. 23-29. Bryan, W.; Siegel, S. **Experience in application of software documentation standards.**

Key words: product assurance; software maintenance; testing; traceability; visibility.

This paper summarizes the authors' recent experience applying software documentation standards contained in MIL-STD-483, MIL-STD-1679, and DoD STD 7935.1-S (and its non-DoD counterpart FIPS PUB 38). Several software documentation problem areas are discussed. One problem area is redundancy—the requirement to put the same material (in different form or degree of detail) in two or more documents in the same set. Not only does this redundancy increase project costs and lengthen schedules, it also greatly complicates the life cycle maintenance of the documents. A second problem area is the telescoping of test documents in FIPS PUB 38 and DoD STD 7935.1-S. In these two standards, test procedures and test plans are included in the same document. If test procedures are written concurrently with the test plan, customer modifications to the test plan may partially invalidate the test procedures. A final problem area is that of tailoring software documentation requirements. Software documentation standards should permit sufficient tailoring to cope with project size and complexity without vitiating the documents. The paper includes recommendations for improvements to software documentation standards.

**SP500-94;** 1982 October. 30-35. Orton, J. N. **Case studies, management guidance and quality criteria for software documentation.**

Key words: software documentation; software standards; specifications.

During the past decade increasing demands have been put in accelerating fashion upon the software documentation function in the form of (1) the increasing complexity and scope of radar systems software applications, (2) the increasing information requirements of an increasing variety of Government software documentation standards and specifications, and (3) increasing Government attention to enforcing contractor fulfillment of these requirements.



Westinghouse is attempting to meet these demands by developing (1) Standardized yet non-stultifying approaches to software documentation in acceptance of today's reality of dynamically proliferating and changing Government software standards and specifications; (2) Automatic documentation tools utilizing word processor and computer systems operating initially apart but eventually in concert; (3) A data base, built up from accumulating software documentation experience, designed both to develop overall documentation quality criteria and to minimize the documentation startup effort for future projects anticipated to relate in varying degrees to present projects; (4) Management techniques for putting this documentation process into effect using the most cost-efficient yet ego-sustaining division of labor between the software designer and programmer on the one hand, and the "information specialist" or document format designer on the other.

These ideas will be explained and evaluated in the harsh light of experience over the past year on two Westinghouse radar systems software documentation projects.

**SP500-94;** 1982 October. 36-39. Hannan, T. L.; Wong, A. A. **Experiences in software standard selection and application—A case history.**

**Key words:** Advanced Computer System; selection criteria; software standards.

This paper presents the findings of analyses conducted by the Systems Research and Development Service of the Federal Aviation Administration regarding the applicability of existing software standards to the development and implementation of the Air Traffic Control Advanced Computer System. A brief description of system requirements, acquisition methods, and standardization objectives is presented with a description of the standard review activities and resultant findings. Preliminary conclusions based on these findings are described, and the issues pending resolution are identified.

**SP500-94;** 1982 October. 43-45. Kaplan, H. P. **The development and implementation of uniform ADP documentation standards at FAA.**

**Key words:** documentation categories; documentation elements; uniform documentation standards; user guide documentation standards; user involvement.

This paper chronicles the experiences of the Federal Aviation Administration (FAA) in tailoring uniform documentation standards to the guidelines contained in FIPS PUB 38. The end product which emerged from this effort was an agency directive which defines requirements for technical documents produced during the development of all approved automated data systems. The directive consists of twenty three specific document content standards defined as documentation elements. These documentation elements are further arranged into documentation categories which are guidelines for packaging the elements. This paper also describes the approach employed in developing the standards, significant benefits accruing from the use of the standards, and concludes with a summary of conclusions and additional needs which were a direct result of uniform documentation standards.

**SP500-94;** 1982 October. 53-57. Harman, D. A. **Operations documentation standards—Online, real-time versus offline, batch.**

**Key words:** documentation; operations manual; real-time system.

The FIPS 38 content guidelines for the Operations Manual should include or expand four topics important to real-time processing: hardware configuration; start-up, shutdown, and performance monitoring procedures; error messages; and nonroutine procedures.

**SP500-94;** 1982 October. 58-67. Larson, R. A. **Documentation for operation phase of systems life cycle.**

**Key words:** operation phase; software documentation; systems life cycle; systems management.

This paper is on software documentation requirements during the Operation Phase of automated systems life cycle in the Forest Service. Implementation of these requirements was started in 1978. This encompasses some five thousand programs in a distributed/dispersed environment. The Forest Service has a systems management process covering the systems life cycle which includes this phase. This process has been implemented in our national and field offices with significant success.

The documents to be presented come from the Forest Service Systems Management Manual and Automated Systems Management and Documentation Handbooks. This paper covers the document contents, associated experiences and future plans for managing software in the Operation Phase.

**SP500-94;** 1982 October. 68-75. Kurihara, T. M. **A proposed guideline for documentation of computer programs and automated data systems for the operations phase.**

**Key words:** automated data systems; computer programs; documentation; Federal Information Processing Standards (FIPS); operations phase.

This paper presents a proposal for the third publication of a set of Federal Information Processing Standards (FIPS) publications describing the documentation content guidelines for computer programs and automated data systems for the operations phase. The proposed guideline is necessary to complete the work begun by FIPS Task Group 14 and is in response to the General Accounting Office Report to the Congress of October 8, 1974, "Improvement Needed in Documenting Computer Systems."

**SP500-94;** 1982 October. 80-83. Henry, S. L. **State-of-the-art documentation. What is it? How does it affect documentation standards?**

**Key words:** compatibility; guidelines; procedures; software.

"State-of-the-art," when applied to documentation, describes a process as well as a product. State-of-the-art documentation is accurate, usable and easy to update. It conserves effort in the design, programming and maintenance of computer systems. This paper discusses the effects of software technology on current documentation format and content standards and suggests procedural guidelines which aid in the preparation and maintenance of state-of-the-art documentation.

**SP500-94;** 1982 October. 84-94. Malhotra, A.; Markowitz, H. M.; Pazal, D. P. **The EAS-E approach to documentation.**

**Key words:** English-like; programming language; self documenting.

EAS-E is a programming language integrated with a database management system that is under development at the IBM Thomas J. Watson Research Center. This paper discusses the EAS-E approach to program documentation. EAS-E programs consist of high-level operations on entities, attributes and sets. The syntax has been designed to be compact and readable. This paper compares EAS-E programs to programs in PL/I-DL/I and PL/I-SQL and shows that EAS-E programs are shorter and have much less non-problem-related code. Thus, they can be viewed as "executable documentation."

**SP500-94;** 1982 October. 95-109. Ting, T. C. **ADD: An automated tool for program design and documentation.**

**Key words:** automated tools; program design; program documentation; program document standardization; program testing; software engineering.

An approach which integrates the activities of software design and documentation is proposed, described, and discussed. An automated tool called ADD which uses a data dictionary system is suggested to support this approach. The unified approach not only offers solutions to some of the important documentation problems, but it provides a structured means for better program design and coding. Program design process is enhanced and guided by a structured "design template." Program design documents are generated automatically to serve as "blueprints" for programming. The use of a "program coding template"



provides a structure for coding. Program module interface conditions are automatically generated and controlled from the design specifications. Program modules are tested by using the predesigned and stored test data to certify their correctness.

The structure of the tool is illustrated. How the automated tool may be used and the benefits of such an automated tool are discussed.

**SP500-94; 1982 October. 110-118. Blum, B. I. An approach to computer maintained software documentation.**

**Key words:** computer maintained documentation; documentation requirements; integrated design and documentation.

The use of text processors to manage documentation is quite common in data processing facilities. Consequently, much of the software documentation is produced in this manner. Unfortunately, we are not realizing the full potential of automation in the production of the documentation required for the different phases of the life cycle. This paper shows how one system is being designed to meet the documentation needs of the various users in a cost-effective way. The system was developed for a specific class of application—the moderate sized Information Management System (IMS). However, the approach is readily transportable to other application areas.

**SP500-94; 1982 October. 119-125. Lawrie, L. K. Automated and automatic documentation.**

**Key words:** automated documentation; documentation standards; internal documentation; software engineering.

Software documentation standards should reflect the evolution of software engineering. Moreover, future progress in software development should be expected and allowance for progress should be incorporated in documentation guidelines.

Systems such as the Automated Documentation System may serve as prototypes for producing automated documentation. Both increased productivity and cost savings can be expected from requiring meaningful documentation.

**SP500-94; 1982 October. 131-142. Thies, R. G. Documenting systems security.**

**Key words:** documentation life cycle; systems security.

This paper presents an approach to documenting system security which provides for the threading of security throughout the documentation life cycle. The approach requires that security requirements are thoroughly described in the Functional Requirements Document and that security is specifically addressed as it applies to each subsequent document. Its structure provides for the convenience of security reviews necessary to attain system certification. To describe the approach, revised security sections were prepared for the Functional Requirements Document, System/Subsystem Specification, Test Plan, and Test Analysis Report which are described in the current FIPS PUB 38.

**SP500-94; 1982 October. 143-151. O'Connor, P.; Redwine, S. T., Jr. Using FIPS PUB 38: A practical experience.**

**Key words:** case study; documentation; documentation guidelines; documentation organizations; documentation procedures; structured interview; technical writing.

The paper describes the experience of the authors as they established a technical writing organization for the purpose of preparing computer software documentation with the FIPS PUB 38 Guideline. The evolution of the documentation group within the corporate context is presented along with the methods that were developed for the production of documentation. The pervasive way in which the Guideline influenced the operation and conformation of the group's procedures is discussed. Problems the authors encountered with the use of a standard derived directly from FIPS PUB 38 and the solutions evolved to counter them are shown.

**SP500-94; 1982 October. 152-156. Hegland, R. R. An overview of the Department of Defense Automated Data Systems Documentation Standards—An adaptable standard.**

**Key words:** document types; DoD standard; management options.

This paper describes the contents of the Department of Defense Automated Data Systems Documentation Standards (DoD Standard 7935.1-S). This standard is currently being used by the Army, Navy, Air Force, several defense agencies, and by the Organization of the Joint Chiefs of Staff. A slightly different earlier version served as the point of departure for a federal documentation guideline which was published in 1976. In addition to describing the standard, this paper will discuss some of the management and technical options that may be used while still conforming with the standard.

**SP500-94; 1982 October. 160-164. Grieb, T. Approach to standards for documentation of projects and systems based on requirements of the users of documentation.**

**Key words:** documentation standards; information processing system standards; project management standards.

This paper addresses questions about and possible solutions for the documentation of *information processing systems* and the *projects* which are the vehicles for creating these systems. This paper (1) defines the problems and requirements of the documentation of projects and systems; (2) evaluates existing attempted solutions (i.e., current documentation standards), and (3) proposes a tested and proven approach to new Federal Government documentation standards based on actual requirements.

**SP500-94; 1982 October. 166-171. Zaveler, S. A. A proposed documentation standard based on a system decomposition and information base approach.**

**Key words:** documentation; documentation standards; FADPUG; software engineering; system decomposition; top-down.

A proposal is made for revision of FIPS 38 with regard to viewpoint and content. The viewpoint suggested is that system decomposition (into components, functions, subsystems, actions, or events) serve as the principal basis of document organization, and that the principal document types all have similar informational requirements but differ in degree of detail. The informational requirements specify a data base from which the documents are derived. The principal content changes are: identical paragraph numbering for similar information in all documents; provision for interactive systems, and provision for documentation of project management matters.

**SP500-94; 1982 October. 174-179. Bassler, R. A. Microcomputer systems users need better documentation.**

**Key words:** beginning computer users; documentation; hardware systems documentation; large computer manufacturers; microcomputers; periodical literature and documentation; software documentation; user's groups; verbal documentation.

From the initial pioneering days of microcomputers, documentation has been the weak link between use of the machines and the vast number of potential users. Many of the microcomputer hardware and software suppliers of the early days are now sufficiently large and financially healthy enough to be able to spend resources toward communication with users. The success of the microcomputer has attracted large computer manufacturers to the marketplace. Large manufacturers such as IBM and Xerox are likely to make sure that the user will have documentation that is usable. With the proliferation of microcomputers, user's groups have created a form of documentation that is verbal. This mutual aid made microcomputing survive, if not flourish, during its infancy days of less than adequate documentation. Third parties such as publishers have moved in to fill the void in documentation. Rapid expansion and survival within the micro industry may well depend on the quality of the documentation furnished.



**SP500-94;** 1982 October. 183-188. Dodd, S. A. **Effective bibliographic standards for computer software: Improved documentation and the need for "title page" equivalents.**

**Key words:** bibliographic control; bibliographic standards; computer software; documentation standards; machine-readable data files (MRDF).

Bibliographic control over computerized information has slowly been evolving within the library and information science profession during the last decade. A major landmark that helped to focus increased interest in bibliographic control of computerized information was the inclusion of Chapter 9 on machine-readable data files (MRDF) in the second edition of the *Anglo-American Cataloguing Rules* (AACR2). Publication of these rules in 1978, coupled with a number of other events, including the compilation of a MARC (Machine Readable Catalog) format for MRDF provided some important tools for establishing bibliographic control over the proliferation of data files and computer software. General purpose computer software must be properly identified with sufficient bibliographic data elements to be processed in turn by librarians and information scientists, converted into catalog records and data abstracts, and finally integrated into existing automated retrieval systems. This paper presents procedures on how to identify and describe a computer program and is directed at those government producers who have the responsibility for providing descriptive information on available Federal software, and for seeing that such information reaches its intended audience.

**SP500-94;** 1982 October. 189-196. Maruyama, L. S. **Standards for bibliographic control of machine-readable data files.**

**Key words:** ANSI Z39.2; bibliographic control; FIPS 30; format structure; machine-readable cataloging; machine-readable data files; MARC; MRDF; numeric data files; software summary.

As a prelude to a review of certain standards in the FIPS series, standards in the area of automated bibliographic control are described, the most important being the *American National Standard for Bibliographic Information Interchange on Magnetic Tape* (ANSI Z39.2). This standard format structure for machine-readable bibliographic data has been implemented by different bibliographic applications, and the implementation by the library community, exemplified by the series of formats known as MARC (Machine-Readable Cataloging) that were developed by the Library of Congress, is discussed. The most recent format developed is one for machine-readable data files (MRDF). The analysis and review performed as the format was being compiled have resulted in questions being posed about the elements included in FIPS 30 (Software Summary for Describing Computer Program and Automated Data Systems) and in a suggestion for a new standard to cover numeric data files.

**SP500-94;** 1982 October. 197-202. Butler, M. K. **The computer program abstract as software documentation.**

**Key words:** computer program abstracts; software documentation; standards; information systems.

The computer program abstract, while not universally accepted as a form of software documentation, has long been recognized as a necessary reference document by the computer user community. Users have banded together in cooperative organizations with like computing environments, common disciplines, or a shared need for particular applications software, to promote the use of computer program abstracts as a means of publication, program exchange, and software development cost savings. Compilations of program abstracts have been adopted to describe the contents of computer program libraries and to market the software industry's products.

In 1981, publication of an American National Standard for Computer Program Abstracts was approved, lending an air of respectability to the abstract's claim to a place in the software documentation family. This paper first seeks to define a computer program abstract and to point out its distinguishing features. Then, users and proponents of computer program abstracts are identified, and prior standardization efforts are reviewed, followed by a discussion of the development of the American National Standard.

**SP500-94;** 1982 October. 203-208. Roistacher, R. C. **An integrated machine-readable data documentation system.**

**Key words:** data documentation; machine-readable; text formatters.

The text formatter can serve as a powerful tool for manipulating text of all types. Techniques are described for using body of machine-readable text to generate questionnaires, data dictionaries, data editing materials, and archival documentation for machine-readable data files.

**SP500-94;** 1982 October. 209-214. Henderson, M. M. **Compilation of bibliographic data element dictionaries.**

**Key words:** bibliographic data; data element dictionary; guidelines.

Under sponsorship of the National Technical Information Service (NTIS), a project has been started to compile a data element dictionary (DED) encompassing all the bibliographic data elements used in the processing of Federal documents. These elements include those used in the abstracting-indexing type of processing done by the four major reports-processing agencies (NTIS, Department of Defense, Department of Energy, and National Aeronautics and Space Administration), plus those used in the library-type of cataloging done by the Government Printing Office, with the Library of Congress, based on the family of MARC formats. The purpose of such a DED is two-fold: first, to provide to the reports-processing agencies a tool to guide their consideration of possible further standardization to achieve greater compatibilities and improved cooperative processing among themselves; and secondly, to provide to them and their library counterparts a mechanism by which to explore productive avenues of cooperation and interfacing. This DED is one of several similar efforts now underway or recently completed; the formats used and the experiences gained should be usable by other efforts, perhaps through preparation of guidelines.

**SP500-94;** 1982 October. 215-218. Wellich, H. H. **Capital games: The problem of compatibility of bibliographic citations in data bases and in printed publications.**

**Key words:** bibliographic citations; capitalization practices; database; orthography.

Bibliographic citations taken from the major databases cannot be used in their original form for publication in most American journals because of editors' capitalization practices. These are based on rules invented a long time ago that run counter to normal English orthography and are based merely on tradition. They have no justification from a linguistic point of view, and may even make titles ambiguous. The relevant American Standard ANSI Z39.29, based on the International Standard ISO 4, allows two different styles for titles of monographs or serials, but only one—normal orthography—for titles of articles or papers. Most major databases also use normal English orthographic rules for titles, but some render titles in all capitals, a practice which may also be detrimental to rapid exchange of bibliographic data among different media. While printers may display titles any way they like, journal editors and database producers should adhere to the commonly accepted orthographic standard (followed also by the Library of Congress), namely capitalization of only the first word and all proper names or acronyms in a title. This would make it possible to transmit bibliographic data for references or footnotes directly from a database without time-consuming and error-prone re-editing for capitalization.

**SP500-94;** 1982 October. 225-229. Hines, V. D. **Designing software documentation for non-technical users.**

**Key words:** automated data systems; user manuals.

FIPS PUB 38 provides guidelines for "automated systems" documentation, which includes "User Manuals." The target audience for this documentation—"non-ADP professionals"—



represents an increasing proportion of software users. Documentation for this group should contain the basic information described in FIPS PUB 38, and should meet broad standards of clarity, completeness, accuracy, and ease-of-use. In addition, five specific design techniques are recommended: (1) emphasize procedures for using the software; (2) organize documentation by system function; (3) provide specific and complete examples; (4) develop documentation in two phases, with programmers writing initial version to be modified by user support specialists; and (5) incorporate documentation into user training.

**SP500-94;** 1982 October. 230-235. Marcus, A. **Paper and glass: Graphic design issues for software documentation.**

**Key words:** glass-faced terminal; graphic design; software documentation.

Graphic design principles have been utilized in redesigning the interface for an information management system and for prototypes of typographically enhanced textual programs. These principles are explained and examples of typical formats are shown to indicate the nature of improvements.

**SP500-94;** 1982 October. 236-241. Psotka, J. **Quality issues in on-line documentation.**

**Key words:** authoring; human interface; on-line documentation.

With the increasing use of microcomputers in all areas, the computer is taking on aspects of an appliance that only needs instructions to set up and then starts to work. This makes on-line documentation an important area for research. Suggestions are made here for the human factors aspects of on-line documentation, including a metaphor for guiding novice users; abbreviated menus for expert users; error messages that are polite; HELP statements that do not erase the current display; interfaces that respond to natural language statements; and input-output devices that make use of general skills. Although this view of documentation exceeds traditional print perspectives, it may be necessary to see documentation as part of the structure of a program when it goes on-line. These issues are discussed within the context of an educational software authoring system.

**SP500-94;** 1982 October. 247-255. Thompson, R. J. **Auditing systems documentation.**

**Key words:** data processing documentation; systems documentation.

Chemical Abstracts Service was an early proponent of and has a continuing commitment to standards and guidelines for data processing documentation. Recently, the organization performed an audit to assess the state of health of its system documentation and to determine its current effectiveness in a technical environment which did not exist when standards were first put into effect. The audit process, findings and analyses are presented as one company's set of experiences. It is hoped that these experiences will serve to stimulate others in examining their own systems documentation activities.

**SP500-94;** 1982 October. 256-264. Levenson, C. S. **Use of the Users Manual as a quality control tool.**

**Key words:** quality control; quality control tool; system verification; user information; users manual.

The preparation of user documentation should be viewed as a quality control task. In this task, a documentation specialist reviews the developed system, its user interfaces, and operating procedures to verify that all functions are integrated properly and that user requirements have been met. However, to serve as a quality control vehicle, the Users Manual standards prescribed by FIPS PUB 38 must be modified to stress the user's information needs rather than the system's internal components.

**SP500-94;** 1982 October. 265-273. Hecht, H. **Requirements documentation—A management oriented approach.**

**Key words:** requirements documentation; software management;

software maintenance; software requirements.

The needs of post-design software life cycle phases are not met by present requirements documentation, and it is suspected that large economic losses are thereby being incurred. Requirements documentation is not being kept current, it is frequently too detailed, and the format inhibits use by the management levels that most need it in the later phases. To overcome these obstacles, a hierarchical structure for software requirements documentation is proposed that (a) limits the size of each volume so that it can be easily handled and read, (b) addresses specific information needs at each management level, and (c) is easily maintained. The hierarchical documentation is supplemented by a single volume that contains general project information. Both the structure and the content of suitable documentation are described.

**SP500-94;** 1982 October. 274-278. Gabriel, J. R. **Issues in defining standards for documentation.**

**Key words:** software documentation; standards.

**SP500-95.** Wilson, C. B., ed. **Computer science & technology: Increasing organizational productivity.** Proceedings of the Computer Performance Evaluation Users Group (CPEUG) 18th Meeting; 1982 October 25-28; Washington, DC. *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-95;* 1982 October. 414 p. SN003-003-02427-9.

**Key words:** benchmarking; capacity planning; chargeback systems; computer performance management systems; queueing models; resource measurement facilities; simulation; supercomputers; workload characterization.

These Proceedings record the papers that were presented at the Eighteenth Meeting of the Computer Performance Evaluation Users Group (CPEUG 82) held October 25-28, 1982, in Washington, DC. With the theme, "Improving Organizational Productivity," CPEUG 82 reflects the critical role of information services in the productivity and survival of today's organization. To meet this challenge, the scope of CPE must be expanded to address performance issues in all aspects of information systems (hardware, software, facilities, communications, personnel, policies, and procedures) throughout the system life cycle. The program was divided into three parallel sessions and included technical papers on previously unpublished works, case studies, tutorials, and panels. Technical papers are presented in the Proceedings in their entirety. *These proceedings include the following papers (indented):*

**SP500-95;** 1982 October. 5-9. Spinelli, J. J. **Information systems management.**

**Key words:** concepts; Information Resource Management; Information Systems Management; management-tool; methodologies; strategies; techniques.

A few years ago, John Diebold introduced his ideas on a concept he calls, "Information Resource Management (IRM)." The major premise is that information is a vital, valuable corporate resource. As Diebold himself states, "The organizations that will excel in the 1980s will be those that manage information as a major resource." But, we must carry this concept a few steps further, that is, information is the direct "product" of the total organizational business system. Information is a function of the totality of all organizational resources. IRM is the function that represents the business system encompassed by the organization's own existence that is used to produce and disseminate the information resource.

**SP500-95;** 1982 October. 11-18. Matthews, P. E. **Long-range ADP planning: A Federal agency planning model.**

**Key words:** ADP planning; Federal ADP procurement; life cycle management; long-range planning; systems planning and control.

This paper describes a long-range ADP planning process developed for a large Federal agency with assistance from the MITRE Corporation. The general acceptance of long-range ADP planning took place in the 1960s, with the introduction of planning, programming, and budgeting. Current planning issues include implementing paperwork reduction under the Paperwork Act of 1980 and strengthening internal controls to prevent fraud,



waste, and abuse, under OMB Circular A-123. Because of the volume and complexity of laws, regulations, and policies which impact ADP management, proper integration of Federal regulation into the planning process is a continuing concern for agency ADP planners.

Topics which a Federal agency planning model must address are the functions it performs, the types of organizations required to perform these functions, the tools needed to develop an ADP plan and oversee its execution, and steps to implement the new planning processes. This paper describes the process in terms of: Planning organizations (top management involvement, organization of the function, and integration with operations); planning functions (preparation, execution, and maintenance); and steps to implement the planning model (establishment of formal agency planning; organization of responsibilities and relationships, implementation of a formal life cycle process, approval of interim plans, implementation of planning support databases, and initial plan execution).

**SP500-95; 1982 October. 19-24. Campbell, M. Productivity thru integrated Information Resource Management.**

**Key words:** computer-based applications; data processing; Information Resource Management; productivity.

Applications of technologies occur in the organization in fluid, ambiguous environments with pressures, costs, and risks. A coherent approach for productivity is needed to apply to the mix of technological, organizational and economic issues.

Strategic Information Resource Management involves addressing the situation by integrating the components of information, people, technology and capital within a volatile environment. The methods for working this out can be examined by applying the approach to selected emphases that we notice in the conversations of Data Processing people today.

The framework is as follows: 1. Tensions arise in the application of Data Processing to the organization. 2. We apply resources and viewpoints to the tensions. 3. We can do this on the basis of expressed principles. 4. Organizational learning takes place. 5. There are new tensions. 6. When applied appropriately, the components of this cycle contribute to productivity.

This presentation attempts to apply a rationale for the above process, considering specific current concerns of computer-based applications.

**SP500-95; 1982 October. 27-33. Morrison, T. G. Pricing strategies in procurements conducted under the basic agreement.**

**Key words:** basic agreement solicitations; evaluation of system life costs; teleprocessing services procurements; unbalanced pricing; workload forecasting.

The General Services Administration's Basic Agreement procurement program was implemented for procuring large scale commercial remote computing services. The intent was to provide a flexible pricing environment where major processing requirements could be satisfied with highly discounted customized pricing. In practice, the pricing flexibility has resulted in non-productive vendor gamesmanship. Successful vendors have learned to create pricing strategies which result in evaluated system life costs being a fraction of the actually experienced system life costs. Techniques are available which can create substantial disparities between the evaluated system life costs and the actually anticipated system life costs. By carefully evaluating workload projections and structuring a pricing scheme to fit the evaluation deficiencies a vendor can exploit the deficiencies and dramatically reduce its evaluated cost. Action must be taken by the government community to stop these pricing practices. Mandating that vendors utilize standard commercial pricing practices would help in resolving the problem.

**SP500-95; 1982 October. 41-45. Vincent, D. R. Fulfilling business needs with an on-line system.**

**Key words:** flow of information; on-line system; system performance.

**SP500-95; 1982 October. 51-60. Johnson, L. A.; Milligan, W. R. Conceptual proposal for a COBOL analyzer software tool.**

**Key words:** automated software testing tools; Automated Verification System; COBOL analyzer.

The COBOL language, and automated software testing tools, have been studied in order to design a host independent Automated Verification System for COBOL. The proposed functions and conceptual design of the system are summarized in this paper. To provide a perspective for the capabilities of the proposed system, this paper contains a critique of the COBOL language, a description of methods of software testing, and a characterization of errors in COBOL.

**SP500-95; 1982 October. 65-74. Olson, S. B. Development of a standard performance management strategy for the U.S. Navy.**

**Key words:** capacity management; computer performance evaluation; Navy nontactical data processing; performance management strategy.

The purpose of this paper is to inform the audience of the efforts of NARDAC Pensacola in building a Performance Management program for the U.S. Navy.

The major point of emphasis will be the location of the Performance Management staff as a management staff function and the goal of providing management planning information rather than being a solely technical group engaged in trouble shooting. Also stressed will be the need for skilled people to gain experience with an operating system/hardware suite in various settings to be able to correctly interpret data in the extremely complex environment in which a large scale computer system operates.

The Naval Data Automation Command was formed in the mid-1970's to improve the efficiency of Navy non-tactical ADP through centralized management and standardized procedures.

Central to this goal was the establishment of Technical Support Departments within the seven Navy Regional Data Automation Centers. These departments are to provide technical support not only to the co-located Data Processing Installation, but to provide support in specific areas initially to all NAVDAC activities, and ultimately to Navy-wide ADP activities. The Navy Regional Data Automation Center, Pensacola, has as one of its assigned technical management areas, Computer Performance Evaluation and Configuration Management.

The paper will describe the organization briefly, and outline the steps taken to develop the expertise necessary to provide both tools and consulting services to Navy Customers.

**SP500-95; 1982 October. 75-80. Chandler, P. Development of a methodology for the analysis of system performance indicators.**

**Key words:** computer performance evaluation; performance improvement plan; system performance indicators.

Many organizations are faced with the performance management of old or overutilized computing resources. Often there is no performance improvement plan which addresses the efficient usage of these resources. The development of a performance improvement plan has value to the organization in that a solidly based plan can be developed which seeks to quantify the computer performance. This paper presents a method by which this plan can be developed.

**SP500-95; 1982 October. 81-84. Peterson, J. T. Computer system data needed for capacity planning.**

**Key words:** analytic modeling; capacity planning; computer performance; modeling; models; software monitors.

The data needed for capacity planning comprises a short list, and can be collected with standard software monitors from the systems of the major main-frame vendors and their PCM's. However, most articles on capacity planning do not discuss the data needed in any detail, and many of those that do, do so only for a single vendor, such as IBM. Since the data is the same for any vendor, this paper discusses the data in generic terms, with examples from several vendors. The paper also explains some shortcomings of vendor-supplied software monitors.

**SP500-95; 1982 October. 89-94. Brand, S. Data processing and**



**Key words:** A-123; data processing; computer crime; computer security.

**SP500-95;** 1982 October. 97-106. Chung, K.; Mowafi, O. A.; Sohraby, K. A. **PERFORM—WWMCCS Intercomputer Network (WIN) performance optimization research model.**

**Key words:** analytical; capacity planning; central server; disk; main memory contention; modeling; packet switch; performance evaluation; simulation; trunk; WIN.

A hybrid modeling tool comprising both analytical and simulation models is described in this paper. The model, PERFORM, has been designed for WWMCCS Intercomputer Network (WIN) to be used in support of performance evaluation, capacity planning, and both software and hardware architectural studies for the host computers and the WIN subnetwork. Included in the discussion are details of the host and subnetwork models composing the PERFORM tool, software implementation, and future directions.

**SP500-95;** 1982 October. 107. Rebibo, K. K. **A simulation study of a local area network for a command control center.**

**Key words:** computer performance modeling; computer simulation; local area network.

A proposed architecture for integrating ADP resources at a military command and control center is a local area network. A computer simulation model was developed to study the throughput and performance characteristics of a local area network under various site configurations and workloads.

**SP500-95;** 1982 October. 111-120. Jain, R. K.; Turner, R. **Workload characterization using image accounting.**

**Key words:** computer accounting; representative workload; system monitoring; workload characterization; workload measurement.

Most operating systems record system resource usage during a user session for accounting and billing. The user session consists of running many programs; however, the information is usually not broken down for individual programs. Image accounting consists of recording the usage information as each program image is activated or run. The data recorded by this facility tells us the relative importance of various programs, in terms of CPU usage, paging demands, I/O operations, and people's time. It also provides information on workload characteristics, such as the average number of characters written to a terminal with one output operation. Analysis of this data can provide useful insights on the potential for improvements in system level performance resulting from various possible optimizations. This paper describes techniques that can be used to exploit this information. The methodology is illustrated by actual examples of image accounting data collected from VAX/VMS installations at six universities.

**SP500-95;** 1982 October. 121-126. Bucher, I. Y.; Martin, J. L. **Methodology for characterizing a scientific workload.**

**Key words:** Amdahl's Law; benchmarking; computing environment; large-scale scientific computing; parallel processing; scientific workload; vector processing.

In the Los Alamos environment of large-scale scientific computing there is always a need for the fastest and largest machine on the market, whether scalar, vector, or parallel processor. Therefore, a determination must be made of the particular architecture most suitable for executing our diverse workload. This determination relies on both an accurate characterization of the current workload and a realistic assessment of future research requirements in computing. Studies are in progress to characterize the present and projected workloads of the major computer users within our facility. This paper describes our general approach to this characterization, which has three stages: (1) identification of major resource consumers among approximately 3000 scientific users; (2) qualitative analysis of the consumer workload to assess the nature

and relative importance of current and projected codes, as well as the significance of such peripheral features as I/O and graphics capabilities; and (3) quantitative analysis of the primary codes to determine specific characteristics, such as ratio of vector to scalar operations, average vector length, number of floating point operations, and number of fetches from and stores to noncontiguous memory locations. The results of these analyses will permit a determination of the relative importance to our users of such machine characteristics as scalar, vector, and parallel processing speeds and capabilities before the next major procurement effort.

**SP500-95;** 1982 October. 127-133. Machung, F. J. **Case history: Business driver methodology in a manufacturing logistics application.**

**Key words:** business driver; key volume indicator; materials logistics.

The business driver or key volume indicator methodology offers a means of forecasting data processing computer workload as a function of user planning indicators. This paper is a case history of one model developed in the manufacturing logistics area. The author assumes that the reader is familiar with the fundamental notions of correlation and linear regression.

**SP500-95;** 1982 October. 139-154. Agrawala, A. K.; Tripathi, S. K.; Thareja, A. K. **Design of a software tool for evaluation of computer and communication systems.**

**Key words:** approximation techniques; queuing models; simulation; software package; systems performance.

The Systems Design and Analysis group at the University of Maryland is in the process of designing and implementing a software package aimed at providing the necessary tools for the performance studies of Computer and Communication Systems. Implemented in a user friendly environment, this package will provide the analyst easy access to the state-of-the-art performance modeling techniques including analytic, simulation, hybrid and approximation techniques. The design concepts of the package are presented in this paper.

**SP500-95;** 1982 October. 155-172. Turner, R. **A performance bound for multiprogrammed virtual memory systems.**

**Key words:** memory management; optimal memory allocation; stochastic control theory.

Optimal Memory Allocation and Scheduling of two programs running in a memory constrained environment is investigated. A simple mathematical model, representing the system as a controlled Markov process, is defined. The problem of jointly optimal memory allocation and scheduling is solved for this model using a technique from stochastic control theory. Several improvements in computation time are shown, and a technique for ensuring convergence of the iterative solution algorithm is developed. Numerical examples are given, showing several possibly counterintuitive results.

**SP500-95;** 1982 October. 173-182. Klibaner, R.; Ziegler, C. **An efficient capacity assignment algorithm for computer communication networks with a tree topology.**

**Key words:** algorithm; capacity assignment; computer communication network; tree topology.

An efficient capacity assignment algorithm for a centralized computer communication network having a binary tree topology is designed. The queueing model used consists of Poisson inputs, constant nodal service times, and fixed length packets. Using more exact and realistic analysis methods for the actual queueing time and/or system time that a packet experiences at each merger node, we have been able to design a more efficient capacity assignment algorithm. The results using this algorithm are compared with an existing algorithm to show the improvement that would occur in the design of a centralized computer communication network.

**SP500-95;** 1982 October. 183-187. Graham, G. S.; Lazowska, E.



D.; Sevcik, K. C. Components of software packages for the solution of queueing network models.

**Key words:** network model analysis; queueing network models; software packages.

We describe the various components that are present in most current software packages for the analysis of queueing network models of computer systems. Each type of component serves a specific function. We survey some of the alternative approaches that can be used in implementing each component.

**SP500-95;** 1982 October. 191-194. Alvarez, A. Design of embedded computer monitoring system.

**Key words:** embedded monitoring system; performance measurements.

The design and adaptation of an embedded monitoring system in a military processor has been quite a challenge. Accurate definitions and analysis of monitoring requirements for the embedded system has been one of the more difficult issues confronting the system performance analysts and designers. Designing an embedded Computer Monitoring System for the standard Navy computer is further compounded by the constraints on size and environmental protection.

**SP500-95;** 1982 October. 195-202. Houghton, R. C., Jr. Program instrumentation techniques.

**Key words:** coverage analysis; dynamic analysis; performance monitoring; program analysis; program instrumentation; software tools.

Many tools that perform dynamic analysis of computer programs modify (or instrument) the programs by inserting probes. Typical analyses that are performed by these tools include coverage, tuning, timing, tracing, and assertion analysis. There are four common instrumentation techniques for higher level languages: global, local, trace, and buffered trace. These four techniques are examined for performance differences on a DECSYSTEM-10.

**SP500-95;** 1982 October. 205-211. Dowdy, L. W.; Stephens, L. E.; Perez-Davila, A. Performance prediction in a UNIX environment.

**Key words:** performance prediction; queueing theory; UNIX; validation.

Computer system performance prediction addresses the question, "How and by how much will a certain hardware or software change affect the performance of given computer system?" The difficulties in being able to accurately predict this performance stem from: (a) not having measurement data on the needed parameters, and (b) not knowing how the parameters change with respect to each other as the system changes.

This paper describes a technique to predict the performance of a system as the number of users increases. This involves predicting the user response time and the user throughput, as a function of the number of users. The thrashing point, where throughput and response times severely deteriorate due to program swapping overhead, is also predicted.

The performance prediction technique is validated on a Perkin-Elmer 3220 running UNIX. To handle the data measurement and parameter interdependency problems, a performance monitor and a synthetic workload are constructed.

**SP500-95;** 1982 October. 217-230. Hajare, A. R. A study of disk I/O on a UNIVAC system in the shuttle mission simulator computer complex.

**Key words:** disk I/O; hardware monitoring; performance measurement; Shuttle Mission Simulator; UNIVAC.

The UNIVAC 1100/46 in the Shuttle Mission Simulator Computer Complex (SMSCC) had two strings of disk drives with two disk controllers on each string. A Tesdata MS-88D hardware monitor was used to obtain measures of disk usage and disk controller usage. The data collected showed that, under Exec Level 36, the load was balanced between the two controllers on

a string. The 8450 fixed disk with the swap file (which was not always the same disk) was used much more than any of the others and it showed a daily variation similar to terminal usage. The I/O activity at the 8450 disks was extremely unbalanced when an empty disk was introduced into the system or when a large amount of space was freed on one disk. This imbalance was caused by all temporary files and all newly catalogued files being placed on the disk was least full, and it resulted in very degraded terminal response.

**SP500-95;** 1982 October. 231-257. Tibbs, R. W.; Kelly, J. C. The application of analytic and simulation models to size a large computer system.

**Key words:** modeling; performance evaluation; simulation; UNIVAC systems.

Martin Marietta Denver Aerospace, with the aid of Datametrics System Corporation, recently performed a comprehensive study of the performance and capacity of a government computer system and several short and long range alternatives. Performance measurement data were collected periodically from the current systems. These data were reduced and analyzed using the Statistical Analysis System, SAS, and were used as input to the modeling packages BEST/1 and SLAM. Models in each package were evaluated and predictions were used to propose one of several alternative systems.

**SP500-95;** 1982 October. 259-273. Bays, W. N.; Voegeli, D. L. A UNIVAC workload characterization system.

**Key words:** capacity planning; job accounting; resource management; statistical analysis; workload characterization.

Analytic modeling, simulation, and benchmarking are major tools for computer performance evaluation. All require an accurate characterization of the system workload. A statistical analysis package has proven useful for workload characterization and other analyses of system accounting. This paper describes the use of P-STAT for workload characterization on UNIVAC systems.

**SP500-95;** 1982 October. 279-296. Irwin, B. RMF equations: Obtaining job class level results from RMF.

**Key words:** application of basic queueing theory; IBM's RMF; job class; mathematical modeling; performance/modeling data acquisition; software monitor.

RMF (Resource Management Facility, IBM's large system software monitor) is an IBM software monitor program product which runs at nearly every large scale IBM installation. RMF is the de facto performance tool for performance analysis, problem determination, and capacity planning. Yet, RMF is not adequate for analysis at the job class level, and virtually impossible to use as a source of input for mathematical modeling of the CPU. It is the purpose of this paper to develop a set of RMF equations, which when applied to RMF monitor measurement data, will obtain for the analyst, job class level results for machines which process multiple job classes. The RMF equations represent a productivity aid to the analyst. These equations will amplify the utility of RMF, extend the capabilities of RMF, and offer the analyst more insight into system performance and behavior.

**SP500-95;** 1982 October. 297-311. Halbig, D. G. Service level management through workload scheduling.

**Key words:** batch; DSNAMES ENQUEUE conflict management; MVS SRM; resource-sensitive job scheduling; service levels; SMF exits; workload scheduling.

The author describes techniques for managing batch workloads in the IBM environment using controls other than the MVS System Resource Manager (SRM). Problems of DSNAMES ENQUEUE conflict management, tape and disk space over-allocation, and resource-sensitive job scheduling are addressed. Results of implementing workload scheduling at the author's installation are presented.

**SP500-95;** 1982 October. 313-320. Chatfield, G. F. Event driven



measurements of MVS that improve configuration tuning and modeling.

Key words: data tuning; modeling; MVS; performance measurement data; software tuning.

**SP500-95;** 1982 October. 321-329. Tetzlaff, W.; Beretvas, T. A new approach to VM performance analysis.

Key words: CPU utilization; queue drops; VM monitor; VM performance analysis.

In the past VM performance analysis centered around resource utilization, and more specifically around CPU utilization. In this paper the concept of state sampling is used to characterize the system responses to interactive users. We will show how to break the response time into its components and consequently how to locate the limiting resource effecting response time.

**SP500-95;** 1982 October. 331-359. Story, J. A VM/SP performance management information system.

Key words: graphical presentation; IBM VM/SP; performance evaluation; performance measurement; performance prediction; VMAP.

The analysis and capacity management of any computer system requires data to be collected on a periodic basis. This data can become voluminous and is very often difficult to present in any understandable manner. The purpose of this paper is to present an outline of a Performance Management Information System, and to show how it was implemented at Texas Instruments on an IBM VM/SP system running mostly CMS users. This system gathers the data, analyzes the data, archives the data, produces reports and graphical displays of the data, on a periodic basis.

**SP500-95;** 1982 October. 365-373. Ramakrishnan, K. K.; Tripathi, S. K. A common framework for studying the performance of channel access protocols.

Key words: carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; throughput; transition matrix.

Channel Access Protocols for shared multiple access channels have been widely studied. Performance studies have treated these protocols in isolation using open system models. For comparing various access protocols, we need to arrive at a uniform framework for the access schemes, operating under similar load conditions. We consider a closed system with a fixed number of users utilizing the channel. The channel is aggregated to a single load dependent M/M/1/N server.

Within such a framework, the adaptability of the channel access protocol to changes in the offered load is studied. The Relaxation Time of the channel is proposed as a measure of the sensitivity of the channel to such changes. Example access schemes are studied. In particular, Fixed Time Division Multiple Access (FTDMA), Slotted Aloha, and Carrier Sense Multiple Access (CSMA) schemes are compared.

**SP500-95;** 1982 October. 375-388. Marathe, M.; Hawe, B. Predicting Ethernet capacity—A case study.

Key words: Ethernet; Ethernet performance; Ethernet simulation; higher level protocols; interactive program development; layered architecture; time-sharing; user level workloads.

"How many users can I support if I install an Ethernet in my installation?" This is a question asked by many installation managers these days. Their worry is understandable because Ethernet bandwidth requirements of a typical user are not widely known. In this paper we estimate these requirements for a specific environment and a specific communications protocol. The environment chosen for this study was the program development or the time-sharing environment in a large University. The communications protocols assumed were similar to the existing Decnet protocols. The methodology presented here can be applied to other environments and protocols as well.

In order to calculate the Ethernet bandwidth requirements of a

typical user we used a two step approach. First, we measured how users are using an existing timesharing system, and then we extrapolated this usage to a hypothetical Ethernet based timesharing system. We assumed that users on an Ethernet based timesharing system will issue the same commands as they do on present systems. This will be true at least initially. We therefore used workload measurements we had performed at several large Universities which do not currently have Ethernet based timesharing systems. On an Ethernet based system, commands issued at a terminal will cause data and control packets to be transmitted over the Ethernet. Depending on the configuration and the communication protocol used, some fraction of the characters to and from the terminals, to and from the disks and to the printers will be transmitted over the Ethernet. In order to make this distributed system work, there will also be some protocol control packets. We combined the user data packets and the protocol control packets together and calculated the total load offered by each user. We then used a packet level simulation model of the Ethernet to estimate the number of users at which the Ethernet will be saturated.

Our results indicate that several thousand users were required to saturate the Ethernet. We therefore expect that in this environment, other components such as the processors or disk servers will become bottlenecks before the Ethernet bandwidth is exhausted.

**SP500-95;** 1982 October. 389-396. Herskovitz, J. Evaluating local network performance.

Key words: computer network; local networking; mathematical modeling; measurement; network performance; performance evaluation.

This paper examines the factors involved in evaluating the performance of a local computer network. The configuration of the network consists of multiframe Digital Equipment Corporation (DEC) and Control Data Corporation (CDC) host computers connected using Network System Corporation (NSC) HYPERchannel Adapters. Software and hardware measurement experiments were implemented to definitize the performance characteristics of major subsystem components in the network system such as host computer, network adapter and interfacing channels. Measurements compare the contributions of host protocol overhead with network adapter processing and trunk transfer rates in defining network performance.

**SP500-95;** 1982 October. 401-407. Christ, M. 327X emulator package for system response time evaluation.

Key words: accurate data; end user; host independent; monitor; network; performance; remote; response time; series/1; sidestreaming; simulated commands; 327X emulator.

The purpose of this paper is to introduce the 327X emulation package as a unique, state-of-the-art performance evaluation tool. The main objective of this package is to measure the system availability that a typical end user experiences. This monitoring tool was developed to address the many problems encountered when attempting to accurately measure, and in turn provide data that adequately reflects actual user response time. The emulator package focuses on this problem by using a Series/1 to simulate a remote 327X user. In simulation, the emulator issues commands and calculates the transaction turnaround time. With its ability to measure response in a controlled environment, utilizing sidestream processing, this IBM internal use only response monitor provides an optimal solution to the problems plaguing 'pre-emulator' monitors.

**SP500-95;** 1982 October. 409-413. Proppe, M.; Wallack, B. The design and application of a remote terminal emulator.

Key words: interactive system; performance evaluation; remote terminal emulation; remote terminal emulator; system under tests.

This paper discussed the design and application of a Remote Terminal Emulator (RTE) developed by Computer Sciences Corporation (CSC) for the Command and Control Technical Center (CCTC). This RTE will be used in the Worldwide Military Command and Control (WWMCCS) community for testing network component performance and new versions of



software prior to release. The topics covered include the functional capabilities of the RTE, the significance of these capabilities in achieving design goals, and the use of the RTE as a performance evaluation tool.

**SP500-95;** 1982 October. 415-421. Ets, A. R.; McCabe, J. H. **Design of an external test driver for performance evaluation.**

Key words: external test driver; performance evaluation; remote terminal emulation; system design; teleprocessing systems; testing.

The procedure for benchmarking a teleprocessing-oriented ADP system is expensive and complex. Current approaches, whether manual or computer-based, are labor intensive and produce inconsistent data. An external test driver which can emulate a number of remote devices promises to reduce costs and improve the accuracy of teleprocessing benchmarking. Current test drivers are very specialized and therefore limited in general application. Generalized external test drivers can be cost-effective if their base of application is broad enough and if their test input and output processes can reduce personnel requirements. This paper presents a design for such a generalized external test driver. The design is independent of target systems and incorporates many features which support the test director. These features include scripting the test, defining test data, running the test, and analyzing the resultant data. Technically, the design is based on remote terminal emulation, with emphasis on simplified station characteristic definition, transparency to the system under test, and driver efficiency. When implemented, the design will provide externally-driven testing for a broad range of applications such as benchmarking, configuration management, software upgrade verification, stress testing, and system enhancement studies.

**SP500-95;** 1982 October. 425. Halstead, D. **Tutorial on charging systems in the Federal Government.**

Key words: billing systems; chargeback systems; charging systems; cost accounting; costing; DP accounting; pricing.

On September 16, 1980 the Office of Management and Budget (OMB) issued its Circular No. A-121 entitled "Cost Accounting, Cost Recovery, and Interagency Sharing of Data Processing Facilities. This Circular requires Federal agencies to implement policies and procedures to (1) account for the full cost of operating data processing (DP) facilities, (2) allocate and report all DP costs to users according to the services received, (3) recover DP costs from external DP users, (4) recover DP costs from internal users when deemed appropriate by the agency, (5) share excess DP capacity with other agencies, and (6) evaluate interagency DP sharing as a means of supporting major new DP applications. In order to satisfy these requirements, Federal agencies will have to develop and implement a DP charging system. Circular A-121 clearly reflects the desire of the Federal Government to begin to manage its DP facilities in a more business-like manner.

By requiring most Government DP facilities to implement a DP charging system, OMB has followed the lead established by many private industry organizations over the last ten years. During this time, private industry took a closer look at the role DP charging systems have in enabling senior management to better manage DP facilities. Many senior officials determined that (1) managing the DP facility should be no different than managing any other department in the organization and (2) installing a DP charging system helps to manage the DP facility like other departments. This point-of-view resulted in a dramatic increase in the number of private industry organizations installing DP charging systems.

Clearly the time has come when all Federal DP managers need to take a closer look at the managerial and technical issues involved in the development and implementation of a DP charging system. The intent of this tutorial is to help CPEUG attendees gain a better understanding of DP charging systems by providing (1) an introduction to the major managerial and technical issues involved with DP charging systems; (2) a detailed example of the most difficult part of developing a DP charging system, the rate-setting process; and (3) some background information on an upcoming National Bureau of

Standards' Federal Information Processing Standards guideline entitled "Guidelines for Developing and Implementing a Charging System for DP Services."

**SP500-95;** 1982 October. 427-431. Cross, T. B. **Really improving software management.**

Key words: computer tele/conferencing; integrating computer conferencing; management information systems.

In the future new tele/conferencing tools will be used to improve productivity in management information systems. One of these tools called computer tele/conferencing may prove to be an important system in the development and management of software.

**SP500-95;** 1982 October. 433. Smith, C. U. **Application of software performance engineering techniques.**

Key words: performance engineering techniques; software systems.

The objective of this case study is to present the concept of performance engineering, a software engineering discipline used in the development of large-scale software systems to ensure that they meet performance goals. The concept of performance engineering is now well understood and analysis tools and techniques have been developed which facilitate the prediction of performance characteristics of software designs before coding begins. Unfortunately, problems are typically encountered when the techniques are applied to large-scale software systems during their development.

The application of software performance engineering techniques to one such system is described. Emphasis is on the nature of the problems encountered and proposed solutions to them. Suggestions are made for future work in this area.

**SP500-95;** 1982 October. 435. Letmanyi, H. **Tutorial on workload forecasting.**

Key words: life-cycle management; quantitative forecasting techniques; workload forecasting.

This tutorial will provide participants with a detailed overview of the organizational approach to the workload forecasting process. The tutorial is recommended for those who have an interest in forecasting workload requirements via quantitative forecasting techniques.

A brief review of the ADP life-cycle will first be discussed to identify the workload forecasting process as an integral part in the life-cycle management of an ADP system. Next, the tutorial will discuss forecasting in general, and some basic forecasting terminology necessary for the understanding of the remainder of the tutorial. Then, a step-by-step approach to the workload forecasting process will be identified. The importance of having definite objectives and goals prior to performing a forecasting process will be discussed. Emphasis will be placed on the importance of an organizational approach to forecasting by translating mission requirements into processing requirements (through workload levels) either in terms of ADP operation or resource usage requirements. Also, the analysis of the forecast results will be discussed.

**SP500-95;** 1982 October. 437. Lazowska, E. D.; Sevcik, K. C. **Analyzing queueing network models of computer systems: A tutorial on the state of the art.**

Key words: efficient evaluation algorithms; modelling; queueing network models.

This tutorial describes recent advances in evaluating queueing network models—obtaining performance measures such as utilization, residence time, queue length, and throughput from parameters such as workload intensities and loadings. These advances make it possible to quickly evaluate models of large systems (hundreds of devices and dozens of workload components) and to incorporate system characteristics such as memory constraints, priority scheduling, and complex contemporary I/O subsystems.



**SP500-95;** 1982 October. 439-441. Reed, S. K. **Categories of backup strategies.**

**Key words:** backup operations; contingency planning; disaster recovery; empty shell; reciprocal aid; recovery center; redundant facilities; shared contingency facility.

The basic strategies for backup operations during recovery from disaster are described. A number of possible variations are included. Some pointers are given in how to select strategies.

**SP500-95;** 1982 October. 443-448. Grant, B. D. **Benchmark construction and validation using synthetic software (A tutorial outline).**

**Key words:** acquisition benchmarks; benchmark construction; forecasting; synthetic software.

This tutorial examines the use of synthetic software in the development of acquisition benchmarks. As such, characteristics of synthetics and the methodology employed to use them effectively are explored. When properly utilized synthetics offer significant advantages over application software in many cases. They are relatively simple to select, modify, and tune to particular benchmark categories and requirements yielding significant savings in time and resources. Acceptance of synthetics has been relatively slow due to problems related to successful mapping of the synthetic to the characteristics of existing and planned workloads and a susceptibility to the effects of optimization. While still worthy of note, these problems may be significantly reduced through proper technique during the developmental process.

**SP500-96.** Rosenthal, R., ed. **Computer science & technology: The selection of local area computer networks.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-96;* 1982 November. 133 p. SN003-003-02451-1.

**Key words:** feature analysis; guidelines; local area networks; local network specification; requirements analysis.

These guidelines present features available in contemporary local area computer networks including distinctions between network applications, topology, protocol architecture and transmission media. Guidance is given to identify the installation's needs. These needs are described in terms of network reliability, traffic characterizations, expected growth, and maintenance requirements.

**SP500-97.** Gray, M. M. **Computer science & technology: Federal ADP equipment: A compilation of statistics—1981.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-97;* 1982 November. 104 p. SN003-003-02450-3.

**Key words:** disk units; Federal Government computers; Federal minicomputers; Federal statistics; general purpose computers; magnetic tape units; terminals.

This report presents data on the status of computer technology in the Federal Government. The report contains a combination of existing statistics from Federal Government and computer industry sources and original analyses and statistics based on these sources. Data is included on CPUs, disk units, magnetic tape units, I/O controllers, terminals, printers, plotters and other related ADP equipment. Analyses are included on the acquisition dates of CPUs, equipment installed by agencies, the purchase-price ranges of equipment, and the type and size class of general purpose computers in the Federal Government compared with the United States. The report is based on Federal Government data from 1971 through December 31, 1981 and industry data from 1972 through 1980.

**SP500-98.** Powell, P. B., ed. **Computer science & technology: Planning for software validation, verification, and testing.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-98;* 1982 November. 89 p. SN003-003-02449-0.

**Key words:** automated software tools; software lifecycle; software testing; software verification; test coverage; test data generation; validation.

Today, providing computer software involves greater cost and risk than providing computer equipment. One major reason is hardware is mass-produced by proven technology, while software is still produced primarily by the craft of individual computer programmers. The

document is for those who direct and those who implement computer projects; it explains the selection and use of validation, verification, and testing (V,V&T) tools and techniques for software development. A primary benefit of practicing V,V&T is increasing confidence in the quality of the software. The document explains how to develop a plan to meet specific software V,V&T goals.

**SP500-99.** McCabe, T. J. **Computer science & technology: Structured testing: A software testing methodology using the cyclomatic complexity metric.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-99;* 1982 December. 72 p. SN003-003-02456-2.

**Key words:** measures; metric; program complexity; software testing; structured testing.

Various applications of the Structured Testing methodology are presented. The philosophy of the technique is to avoid programs that are inherently untestable by first measuring and limiting program complexity. Part 1 defines and develops a program complexity measure. Part 2 discusses the complexity measure in the second phase of the methodology which is used to quantify and proceduralize the testing process. Part 3 illustrates how to apply the techniques during maintenance to identify the code that must be retested after making a modification.

**SP609.** Heaton, H. T. II, ed. **Proceedings of a meeting on traceability for ionizing radiation measurements.** Proceedings of a meeting held at the National Bureau of Standards; 1980 May 8-9; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 609;* 1982 February. 175 p. Available from: NTIS; PB 82-178146.

**Key words:** calibrations; ionizing radiation; measurements; national standards; quality assurance; secondary standard laboratory; traceability.

These proceedings are the compilation of 21 papers presented at a seminar on Traceability for Ionizing Radiation Measurements held at the National Bureau of Standards, Gaithersburg, MD, on May 8-9, 1980. General concepts of traceability were presented from several perspectives. The national standards for radiation dosimetry, radioactivity measurements, and neutron measurements were described. Specific programs for achieving traceability to the national standards for radiation measurements in medical, occupational, and environmental applications were summarized. *These proceedings include the following papers (indented):*

**SP609;** 1982 February. 3-10. Eisenhower, E. H. **Traceability—A view from the NBS Center for Radiation Research.**

**Key words:** calibrations; instruments; ionizing radiation; measurements; measurement support system; quality assurance; standards; traceability.

This paper presents general information about the traceability of ionizing radiation measurements to the appropriate national physical measurement standards. It describes fundamental concepts that should serve as the basis of more specific considerations of traceability, some common problems encountered in making statements about traceability, and the means and methods used to achieve traceability. Distinctions between the two principal types of traceability (instrument and measurement) are identified and the differences in the ways they are achieved are summarized. Some of the ambiguities that may occur in statements about traceability are recognized, and preferred ways of making unambiguous statements are given. The importance of means and methods for achieving traceability is emphasized, since statements about traceability have limited usefulness unless the specific means and methods can be identified for a particular measurement under consideration. The technical and institutional elements that provide these means and methods constitute the national measurement support system. Present weaknesses in this system are identified, and two measurement quality assurance programs are described as examples of how the system can be improved.

**SP609;** 1982 February. 11-17. Kathren, R. L. **Traceability of radiation measurements: Musings of a user.**

**Key words:** calibration; definitions; hierarchy of standards;



National Bureau of Standards; radiation; standards; traceability.

Although users of radiation desire measurement traceability for a number of reasons, including legal, regulatory, contractual, and quality assurance requirements, there exists no real definition of the term in the technical literature. Definitions are proposed for both traceability and traceability to the National Bureau of Standards. The hierarchy of radiation standards is discussed and allowable uncertainties are given for each level. Areas of need with respect to radiation standards are identified, and a system of secondary radiation calibration laboratories is proposed as a means of providing quality calibrations and traceability on a routine basis.

**SP609; 1982 February. 19-27. Jennings, W. A. Radiation measurement traceability in the United Kingdom.**

**Key words:** calibrations; codes of practice; ionizing radiation; regulations; standards; traceability; type testing.

The concept of traceability in the UK, along with the role of the National Physical Laboratory, is presented. In respect of the measurement of ionizing radiations, the legal position in the UK is summarised and a three-tier system of Regulations, Codes of Practice and Guidance Notes is described, with particular reference to the field of radiological protection. The impact of the relevant European Directive in this field, and the preparation of the consequential Ionizing Radiation Regulations in the UK, are discussed, including the need for type-testing, etc. The role of the British Calibration Service, including the operation of personal dosimetry services is introduced. Radiotherapy calibrations, radioactivity measurements, and industrial radiation processing are then considered, and finally, the role of the various international links is mentioned.

**SP609; 1982 February. 29-30. Loevinger, R. National standards for radiation dosimetry.**

**Key words:** calorimeter; cavity ionization chamber; extrapolation chamber; free-air chamber; ionizing radiation; measurement standards; radiation dosimetry; standards.

NBS measurement standards for radiation dosimetry, the radiations with which they are used, and the corresponding calibration uncertainties, are described briefly.

**SP609; 1982 February. 31-37. Cavallo, L. M. National standards for radioactivity measurements.**

**Key words:** calibration; intercomparisons; measurements; radioactivity; standards; system.

The National Bureau of Standards provides the foundation of the National Radioactivity Measurements System: radioactivity Standard Reference Materials, calibration services, measurements assurance programs, and traceability to the international radioactivity measurements system.

**SP609; 1982 February. 39-43. Grundl, J. A. National standards for neutron measurements.**

**Key words:** calibration; neutrons; standardization.

Brief description of NBS capabilities for neutron measurement standardization is provided along with a characterization of these activities in the context of traceability and measurement assurance.

**SP609; 1982 February. 45-58. Heaton, H. T. II. NBS services for ionizing radiation measurements.**

**Key words:** calibration; ionizing radiation; measurement; national standards; quality assurance; standard reference material; traceability.

The NBS measurement support services relevant to establishing traceability to the national standards for ionizing radiation are described. These services can be grouped into four categories: calibrations, standard reference materials, measurement quality assurance services, and special services. Within each category, the services for photon and electron dosimetry, radioactivity measurements, and neutron

measurements are summarized.

**SP609; 1982 February. 59-64. Ohlhaber, T. R. The calibration program of the Bureau of Radiological Health.**

**Key words:** calibration; instruments; measurements; standards; traceability; x ray.

The x-ray calibration program of the Bureau of Radiological Health is described including users, workload and relationship to Bureau programs. Traceability of field measurements to national standards through this laboratory are discussed.

**SP609; 1982 February. 67-75. Campbell, G. W.; Elliott, J. H. The LLL Calibration and Standards Facility.**

**Key words:** calibration instruments; calibrations; calibration techniques; standards; traceability.

The capabilities of Lawrence Livermore Laboratory's Calibration and Standards Facility are delineated. We describe the facility's ability to provide radiation fields and measurements for a variety of radiation safety applications and the available radiation measurement equipment. The need for national laboratory calibration labs to maintain traceability to a national standard are discussed as well as the areas where improved standards and standardization techniques are needed.

**SP609; 1982 February. 77-79. Neuweg, M. State of Illinois Regional Calibration Laboratory.**

**Key words:** facility design; future plans; implementation; objectives; purpose.

The State of Illinois, Department of Public Health, is engaged in a pilot project with the National Bureau of Standards to establish a regional calibration facility. The objective of this project is to provide calibration services for state radiation control programs for radiation measurement instruments utilized in the diagnostic x-ray energy range. Rationale for the pilot project and the design and implementation phases of the calibration laboratory facility are discussed.

**SP609; 1982 February. 81-88. Shalek, R. J.; Humphries, L. J.; Hanson, W. F. The American Association of Physicists in medicine's regional calibration laboratory system.**

**Key words:** calibration; field instruments; national radiation standards; radiation therapy.

Three Regional Calibration Laboratories have been established primarily for the dissemination of national radiation standards for radiation therapy. The National Bureau of Standards together with the regional laboratories have a calibration capacity in rough equilibrium with the demand. However, if all instrument users had field instruments calibrated regularly the demand might exceed present calibration capacity. Various data are adduced to demonstrate that commercially available field instruments can maintain calibrations for periods longer than the generally recommended 2 year interval.

**SP609; 1982 February. 89-97. Soares, C. G.; Ehrlich, M. NBS traceability programs for radiation therapy.**

**Key words:** cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; survey; teletherapy; thermoluminescence dosimetry; traceability.

Traceability of the calibration of radiation therapy machines to the national dosimetry standard may be verified by means of a measurement assurance program. Such a program often involves the use of rugged dosimetry systems for establishing a direct link between the user and the primary calibration laboratory without personal visits. In this paper, procedures common to this type of therapy dosimetry survey systems are discussed. Then, to illustrate these procedures, three of these systems are treated in detail: (1) the ferrous sulfate (Fricke) dosimetry system used at NBS in an ongoing survey of electron-therapy dosimetry, (2) a TLD system that was used by NBS in a one-time study of cobalt-60 teletherapy dosimetry, and (3) a second TLD system proposed for surveying megavoltage bremsstrahlung therapy dosimetry.



**SP609; 1982 February. 99-110. Golas, D. B. Traceability programs for nuclear medicine.**

**Key words:** assurance; measurements; radioactivity; radiopharmaceutical; standards; traceability.

The National Bureau of Standards (NBS) supervises and administers two measurements assurance programs: one on behalf of the Atomic Industrial Forum (AIF), representing several manufacturers of radiopharmaceuticals; and the other with the College of American Pathologists (CAP), representing hospitals and final users of radiopharmaceuticals. Each program is described and the results of measurements of samples of known, but undisclosed, activity are presented.

**SP609; 1982 February. 111-116. Gesell, T. F.; Jones, M. F.; de Planque, G. The role of calibration standards in environmental thermoluminescence dosimetry.**

**Key words:** calibration; dosimetry; environmental; intercomparison; standards; thermoluminescence.

The nature of the environmental radiation field is briefly reviewed and its complexity of composition and energy emphasized. The needs and appropriate standards for environmental dosimetry are discussed and calibration procedures are examined. The international environmental dosimeter intercomparison program is reviewed. Data from the intercomparison program are used to show that only a small part of the error associated with environmental TLD measurements is likely to be due to uncertainty in the calibration standard. Other problems of the calibration process are discussed.

**SP609; 1982 February. 117-127. Inn, K. G. W.; Noyce, J. R. The National Bureau of Standards low-level radioactivity-measurements program.**

**Key words:** calibration; environment; natural material; radioactivity; radionuclide; standard; traceability.

The National Bureau of Standards low-level radioactivity measurements program is oriented towards the production of reference materials for environmental radioactivity measurements needs. These reference materials are used 1) for calibration of instruments, and 2) as test sources for analytical procedure evaluation. These endeavors are designed to provide the nation with a means of assessing the quality of environmental radioactivity measurements and relating them to national and international radioactivity standards. The present status of these efforts is discussed along with possible future plans.

**SP609; 1982 February. 129-133. Cohen, L. K. NRC traceability concerns in its inspection and enforcement program.**

**Key words:** enforcement; inspections; NRC; radiation measurements; regulations; regulatory guides; traceability.

This paper discusses NRC's traceability requirements in the licensing process and in its inspection programs. It describes the approach and direction NRC has taken to achieve traceability for its own program and to provide a means for the licensee as well.

**SP609; 1982 February. 135-143. George, A. C. Radon and radon daughter field measurements.**

**Key words:** environmental measurements; radon; radon daughters.

Practical methods for measuring the concentration of radon and radon daughters in air are reviewed, and procedures and instruments are recommended for reliable field measurements.

**SP609; 1982 February. 145-148. Plato, P. A. Performance testing of personnel dosimetry services.**

**Key words:** dosimeters; NRC; pilot study; sources; standard; traceability.

From 1977 to 1979, The University of Michigan conducted a

pilot study of a dosimetry performance testing standard that the Nuclear Regulatory Commission is considering as the basis of a mandatory testing program for dosimetry processors that service their licensees. This paper discusses the traceability of the radiation sources used in the pilot study to the National Bureau of Standards and summarizes the results of the pilot study.

**SP609; 1982 February. 149-169. Brodsky, A. Occupational exposure measurements in NRC regulatory guides.**

**Key words:** accuracy; bioassay performance; occupational radiation protection standards; performance criteria; quality control; radiation instrument performance; radiation measurements; regulatory standards.

Since the formation of the Nuclear Regulatory Commission (NRC), a series of guides on occupational radiation protection standards have been developed. These guides include information on acceptable accuracy and quality control of most types of radiation survey measurements for internal and external exposure assessment. However, more complete specifications of precision, accuracy, and traceability requirements are under development, and programs are underway to establish measurement systems for monitoring and certifying licensee compliance with quality control and accuracy standards. Many fundamental measurement principles and radiation protection concepts are involved in these developments, and they must be better understood and applied to properly establish these systems.

**SP609; 1982 February. 171-178. McLaughlin, W. L.; Humphreys, J. C.; Miller, A. Dosimetry for industrial radiation processing.**

**Key words:** calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability.

In the dosimetry related to sterilization of goods by ionizing photons and electrons, and in other industrial radiation applications, i.e., modification of plastic and other materials, food preservation, and treatment of waste products, it is important to have traceability to standard absorbed dose measurements. The preferred primary methods of dosimetry for large radiation doses ( $>10$  Gy) are: (1) Calorimetry, which is suitable for both electron and photon radiations; (2) Standard chemical dosimetry, in particular, ferrous sulfate dosimetry, which, because of its relatively narrow response range (40-400 Gy) and rate dependence at dose rates  $>10^7$  Gy·s<sup>-1</sup>, is mainly suited to x- and gamma radiation. Using these techniques as primary reference methods, it is possible to calibrate the response characteristics of routine dosimeters, such as plastics, dyed plastics, and solid-state sensors in terms of a reproducible signal versus known values of absorbed dose. Dose levels and dose gradients within a sizable irradiated volume, e.g., produce packages, are determined within specified values of uncertainty, which may be set in terms of statistical error and precision in making practical interpretation of dose and dose limits.

**SP619. Small, J.; Steel, E., eds. Asbestos standards: Materials and analytical methods. Proceedings of the NBS/EPA Asbestos Standards Workshop held at the National Bureau of Standards; 1980 October 1-3; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 619*; 1982 March. 220 p. SN003-003-02388-4.**

**Key words:** asbestos standards; asbestos statistics; electron microscopy; fibrous minerals.

This publication contains the invited papers which were presented at a workshop on asbestos standards jointly sponsored by the Environmental Protection Agency and the National Bureau of Standards and held on October 1-3, 1980. The workshop was divided into five sections: (1) Bulk Materials for Preparation of Asbestos Standards....This section includes descriptions of natural and synthetic materials which have a potential use as standards for asbestos analysis. In addition, it also includes a description of the NBS Standard Reference Materials Program. (2) Standards Preparation....The electron-microscopy preparation procedures for standards mimicking airborne and waterborne asbestos samples are described. (3) Asbestos Analysis for Standards Certification....This section describes analytical procedures and problems associated with



the intra- and interlaboratory analyses of asbestos standards. (4) Error Analysis and Statistics...This section describes the statistical considerations which are involved in asbestos standards preparation and analysis. (5) EPA Provisional Method...Current developments and selected problems with the EPA Provisional Method for Electron Microscope Measurement of Airborne Asbestos Concentrations are discussed.

The papers include general reviews on each of the subjects as well as specific papers detailing current research efforts. *These proceedings include the following papers (indented):*

**SP619; 1982 March. 1-4. Beard, M. E. Quality assurance for airborne asbestos measurements.**

**Key words:** airborne asbestos fibers; electron microscopic analysis; EPA-NBS agreement; methodology manual; standardized measurement protocol.

An EPA program designed to provide quality assurance for measurement of airborne asbestos fibers is outlined. The program provides for the development of (1) a standardized measurement protocol and (2) a characterized reference material suitable for performance evaluation. A provisional methodology manual (EPA Report 600/2-77-178) describing transmission electron microscopic identification of asbestos fibers is being evaluated under contract. Critical subroutines involving sampling, sample preparation, and analysis are being investigated and the resulting information will be used to optimize the current protocol. The resulting protocol will be subjected to a multilaboratory collaborative test designed to determine precision and accuracy of the method. A concurrent EPA-NBS agreement is designed to produce reference materials for use in performance evaluation of electron microscopic analysis of asbestos fibers. The materials will be in the form of prepared grid specimens and coated sample filters. These standards will allow identification of variabilities due to sample preparation and counting. The program is scheduled for completion in late 1981.

**SP619; 1982 March. 5-20. Graf, J. L.; Draftz, R. G.; Haartz, J. C. Asbestos reference materials: Sources and characterization.**

**Key words:** asbestos; asbestos analysis; asbestos standards; characterization; sources.

One of the keys to the successful development of any analytical method is the availability of well-characterized reference materials. The need for asbestos standards is especially acute since research efforts to develop standardized methods of asbestos analysis are currently in progress even though there is an absence of high purity, well-characterized asbestos reference materials. Current knowledge on sources for asbestos reference samples and the extent of their characterization are summarized along with a list of recommendations for the development of additional reference samples based on size and purity.

**SP619; 1982 March. 21-28. Cronin, D. J.; Blackburn, D. H.; Haller, W. K. Glass as a material for asbestos standards.**

**Key words:** analytical standards; asbestos standards; chemical composition; fibers; glass; physical dimensions.

Glasses are finding increased use as analytical standards, particularly for micro-analytical techniques, because they can be produced with a broad composition range and excellent homogeneity and durability. The nature of glass also allows the production in several forms, e.g., bulk, spheres, or fibers.

Glass may prove useful in two areas of asbestos standards, for chemical composition and for physical dimensions.

Some compositions of interest in asbestos studies have been produced as glasses. Others cannot be made as glasses without additions to aid particular properties, such as to reduce melting temperatures or decrease the crystallization tendency. It does appear several compositions of interest could be produced as homogeneous glasses for use as composition standards if desired.

For size standards it would be desirable to have fibers of carefully controlled diameter and length in the range of 0.1  $\mu\text{m}$  diameter and 5  $\mu\text{m}$  long. Suitable fibers for producing such standards are not currently available. However, the theory and experimental work on fiber drawing suggest that it may be possible to alter present techniques to produce such fibers.

**SP619; 1982 March. 29-33. Kirby, R. K. The NBS program for Standard Reference Materials.**

**Key words:** industrial atmosphere; lead; measurement methods; measurement systems; standard reference materials (SRM's).

The Standard Reference Materials (SRM's) program will be described and specific examples given of SRM's and how they aid in measurement compatibility and traceability in the environmental area. An SRM is a material or device for which a chemical or physical property has been certified by the National Bureau of Standards (NBS). SRM's can be used to calibrate measurement systems, to evaluate measurement methods, and to provide traceability of the measurement to NBS. In general, measurements are made at NBS or in cooperating laboratories in such a way that accurate values for the property are obtained and the present best estimate of the true value and its uncertainty are certified. Current SRM's in the environmental and industrial hygiene areas include analyzed gases for atmospheric pollutants such as  $\text{SO}_2$  and  $\text{NO}_2$ ; lead, sulfur and mercury content in fuels and water; quartz, beryllium, and other metals on filters to be used in determining their level in an industrial atmosphere; and trace element concentrations in coal, fly ash, fuel oil, urban aerosols, and water.

The National Bureau of Standards (NBS) has issued Standard Reference Materials (SRM's) since 1906. During most of these years the emphasis has been on metallic compositional reference materials. During the last 10 years, however, there has been a large increase in requests for SRM's in clinical chemistry, nuclear materials, physical science, and electronics as well as in environmental and occupational health areas. Some examples of SRM's in the environmental and industrial hygiene areas are shown in Table 1. Although the concentrations of more than one element are generally certified in these SRM's the concentration of lead, which is of particular interest to the health of individuals, has been indicated in this table.

**SP619; 1982 March. 34-43. Virta, R. L.; Shedd, K. B.; Campbell, W. J. Identification and quantification of asbestos in construction materials using polarized light microscopy: The need for standards.**

**Key words:** asbestos; bulk standards; construction materials; health risk; polarized light microscopy.

The Bureau of Mines Particulate Mineralogy Unit, in cooperation with the Environmental Protection Agency (EPA), conducted a round robin program to evaluate the reliability of analyses of asbestos-containing building materials by polarized light microscopy. This microscopic technique was selected by EPA as the principal analytical method for asbestos identification and quantification in their program to evaluate the potential health risk from exposure to airborne asbestos in public buildings.

Results of the round robin show a need for monomineralic reference samples of asbestos and nonasbestos components of these materials to aid in identification training. Also necessary are bulk standards containing known amounts of asbestos to be used in verification and quality control of quantification techniques.

**SP619; 1982 March. 44-52. Lentzen, D. E.; Brantly, E. P.; Gold, K. W.; Myers, L. E. Preparation of asbestos "standards" for methods verification and laboratory evaluation.**

**Key words:** asbestos; bulk material; laboratory evaluation; optical method; sprayed insulation.

The Research Triangle Institute (RTI) has supported the Environmental Protection Agency's "Asbestos in Schools" program by producing a method for the determination of bulk material asbestos content. The utility of the method was investigated in an interlaboratory test program which included formulated samples and samples of in-place sprayed insulation. Preliminary analysis of the results suggests that a reasonable estimate of asbestos weight percents can be made by application of appropriate correction factors to real percent determinations of optical methods. Laboratory evaluation may be best performed through the use of nonparametric ranking of reported results when standard samples are not available.



**SP619; 1982 March. 53-67. Cook, P. M.; Marklund, D. R. Sample preparation for quantitative electron microscope analysis of asbestos fiber concentrations in air.**

**Key words:** asbestos fiber; biological samples; electron microscope; fiber concentrations; standard samples.

The ability to determine asbestos fiber concentrations and size distributions depends on the electron microscope observation of the particles in very small fields of view that constitute microcosms representative of the total sample. Sample preparation procedures are a critical consideration in the quest for acceptable accuracy and precision because they have a direct influence on the number and size of particles observed. Loss of particles, physical or chemical degradation, particle contamination, alteration of particle size distribution, interference by debris, and non-uniform particle distribution are problems associated with sample preparation procedures. Basic methods for collecting particles suspended in air or water on membrane filters and then transferring them to electron microscope grids will be discussed with respect to these problems. Preparations of biological samples (tissues, food, fluids) and standard samples from dry powders are complicated by the need to manipulate the sample to obtain particle suspensions in water suitable for filtration on a membrane filter. The desirable effects of the use of ashing, chemical digestion, surfactants, sonification, centrifugation, and agitation techniques must be weighed against the possibilities for sample alteration associated with each manipulation of the sample. Results from interlaboratory comparison studies have indicated that different sample preparation procedures frequently result in poor agreement between the laboratories using the procedures.

**SP619; 1982 March. 68-76. Feldman, R. S. Development of an asbestos reference suspension.**

**Key words:** asbestos fiber; asbestos reference suspension; fiber loading; filters; ultrasonic baths.

The objectives were: consistent asbestos fiber numbers and sizes per vial, fiber sizes similar to those in field samples, fiber loading easy to count, no clumps of fibers, no debris, no significant physical and chemical deterioration. Methods include separation and suspension of fibers in 0.1 percent Aerosol OT surfactant, fiber length selection/production by high-power ultrasonication, and uniform dispersal of fibers in surfactant by reciprocal shaking. Vials were used instead of ampoules for quantitative transfer of the 25 mL contents. A filtration "buffer" promoted even dispersal of fibers on filters. Filters were not dried, in order to prevent fiber losses before carbon coating. Low-power ultrasonic baths may cause separation of fibrils. The objectives were met.

**SP619; 1982 March. 77-84. Jones, D. R.; Yamate, G. Preparation of airborne asbestos standards.**

**Key words:** aerosolized fibers; airborne asbestos; analytical methods; contamination; filter loading.

The methods used to generate a set of standard hi-vol and personal samples for use in comparison of analytical methods is described. Various problems of predicting the filter loading, minimizing external contamination, and generation of aerosolized fibers are discussed.

**SP619; 1982 March. 85-90. Melton, C. W.; Anderson, S. J.; Dye, C. F.; Chase, W. E.; Anderson, C. H. Concentration and separation of chrysotile by two-phase liquid separation.**

**Key words:** chrysotile asbestos; electron microscopy; filter; isooctane; liquid separation.

The development of a rapid analytical method for determining chrysotile asbestos in water that requires substantially less time per analysis than electron microscopy methods will be described. Based on the proposition that separation of chrysotile from other waterborne particulate would greatly simplify the task of detection, the research effort was directed toward establishing separation and concentration techniques. This investigation led to the development of a separation procedure whereby chrysotile is

extracted from a water sample into an immiscible organic liquid phase. The procedure is called two-phase liquid separation (TPLS).

TPLS extracts chrysotile from water into isooctane after the chrysotile surface has been rendered hydrophobic by reaction with an anionic surfactant (dioctyl sodium sulfosuccinate). Extraction of the chrysotile from the water phase into the isooctane phase occurs as the two liquids are shaken in a separatory funnel. Agitation creates an emulsion that is broken by adding sodium chloride solution. The isooctane is then filtered to deposit the chrysotile on a filter where its concentration is analyzed by light microscopy or spot test procedures.

**SP619; 1982 March. 91-107. Chatfield, E. J. Analytical procedures and standardization for asbestos fiber counting in air, water, and solid samples.**

**Key words:** aqueous standard fiber dispersions; asbestos analysis variability; fiber identification criteria; interlaboratory calibration; preparation techniques.

Interlaboratory analyses of air, water and mineral samples for asbestos fibers have shown much variability. Sources of error in this type of analysis include fiber losses or size modification during sample preparation, contamination by extraneous fibers, non-uniform deposition on analytical filters, differences between operators in fiber counting philosophy, and use of different criteria for fiber identification. The lack of suitable reliable standard samples has also confused efforts to incorporate good controls when analytical work has been split between several laboratories. Interlaboratory distribution of aqueous fiber dispersions for analysis has been found to be particularly difficult, and in several studies has resulted in a very wide range of reported concentrations from the same sample.

The published EPA interim procedures for determination of asbestos in air and water samples do not specify in detail the topics of fiber identification or fiber counting philosophy. Morphology, selected area electron diffraction, and energy dispersive x-ray analysis, used either separately or in combination can provide adequate fiber identification, depending on prior knowledge about the sample. However, economic considerations usually prevent classification of every fiber into its precise mineralogical species. A fiber classification system is proposed which provides a basis for uniform reporting of fiber counting data; some aspects of specimen preparation and fiber counting techniques are also discussed.

**SP619; 1982 March. 108-120. Riis, P.; Chatfield, E. J. Development of a rapid survey technique for the detection of asbestos fibers.**

**Key words:** asbestos fibers; light scattering; magnetic alignment; magnetic filtration; rapid fiber analysis.

Amphibole and chrysotile asbestos fibers adopt preferred alignment directions when suspended in a strong magnetic field. The alignment direction of the fiber may be parallel to, normal to, or at a specific angle to the flux lines. When an aligned distribution of fibers is illuminated by a collimated beam of light, scattering occurs in which maxima of intensity are observed in all directions normal to the fiber lengths.

The magnetic alignment and light scattering technique is being developed for the detection of asbestos fibers. The current procedure consists of filtration of a liquid sample in a magnetic field of 1.0 Tesla, during which the fibers become aligned before they come into contact with the filter. The mixed cellulose ester filter is mounted on a glass slide and its structure is collapsed by exposure to acetone vapor. The cleared membrane filter is removed from the slide and illuminated by a normal incidence laser beam. The scattered light intensity is measured as a function of the angular position of the original magnetic field direction, and the peaks which occur allow the concentration of aligned fibers to be deduced. This method shows much promise as a rapid survey technique for the presence of asbestos fibers in water samples. It is also possible to distinguish between chrysotile and amphibole asbestos fibers, and even between some specific amphibole varieties on the basis of differences in the profiles of their scattered light distributions.



**SP619; 1982 March. 121-131. Chopra, K. S.; Beaman, D.; Cook, P. Interlaboratory measurements of the chrysotile asbestos fiber and mass concentrations in water samples.**

**Key words:** chrysotile asbestos; fiber; glass; mass concentrations; water samples.

In interlaboratory determinations of the chrysotile asbestos concentrations in water, it was found that: 1. The accuracy in the determination of mass in  $\mu\text{g/L}$  is about 50 percent, and is systematically low, i.e., the average recovery is 50 percent. 2. The precision in the determination of mass and fiber concentration is about  $\pm 50$  percent. 3. The precision of the analyses did not improve during the three years of analyses involving six different chrysotile-containing samples. 4. Water samples retained in glass tend to produce lower mass determinations as the length of storage is increased. 5. Selected area electron diffraction provides highly variable results. In samples where the only fibers were chrysotile, the portion of fibers reported as giving positive SAED patterns varied from 0-97 percent. The average fraction of chrysotile fibers with positive SAED for all investigators and investigations was 47 percent.

**SP619; 1982 March. 132-137. Lee, R. J.; Kelly, J. F.; Walker, J. S. Considerations in the analysis and definition of asbestos using electron microscopy.**

**Key words:** analysis; asbestos; electron microscopy; occupational monitoring; optical microscopy.

The most widely used working definition for asbestos in electron microscopy analysis was established on neither a physical nor health related basis. It derived from the definition applied to occupational monitoring using optical microscopy, without regard for the differences between the two types of instruments. The definition has no lower limit on fiber length and an inappropriate lower limit on aspect ratio. This, plus the reporting of data with poor counting statistics, has detracted from the effective use of electron microscopy in quantifying nonoccupational exposures to asbestos. Thus, much of the time and effort expended so far on this type of analysis has no long term value. The purpose of this paper is not to present new data, but rather to summarize some difficulties with current analyses. Further, we propose for consideration some operational definitions and procedures that are more physically meaningful and cost effective than those presently in use.

**SP619; 1982 March. 138-144. Stewart, I. M. Comments on the achievability of a valid asbestos standard for TEM counting.**

**Key words:** asbestos identification; asbestos standard; electron microscopy; fiber counts; sample preparation.

The validity of any standard reference material is only as good as the validity of the sample preparation and analytical methodology used to characterize the standard. In the case of standards for the determination of fiber counts by electron microscopy, the literature is somewhat vague on the validity and the reproducibility of specimen counting procedures. Most electron microscopists, when questioned on the subject, would generally agree that results are valid within an order of magnitude but to a certain extent this has been a gut-feeling or an inspired guess rather than the results of any tests performed to confirm this. Such round-robin tests as have been performed have generally been confounded statistically by a confusing medley of comparisons between sample preparation methodologies, different instrumentation used for the analyses, and variability in operator experience both on these instruments and of asbestos identification. It is not the object of this paper to further cloud the issue but, instead, to provide some gleam of hope that standards may, indeed, be valid.

**SP619; 1982 March. 145-153. Chase, G. R. Membrane filter method: Statistical considerations.**

**Key words:** airborne asbestos; error distributions; Gaussian assumptions; membrane filter method; statistical considerations.

The historical evolution of the understanding of errors associated with workplace sampling for airborne asbestos using the membrane filter method is presented. Statistical considerations of the membrane filter method are illustrated using analytical and empirical results. Possible sources of error and those which should be considered are discussed. The importance of the form of the distribution used to quantify the reliability of the method is shown using theoretical and empirical findings. In particular, it is shown that Gaussian assumptions can be very misleading when the error distributions are skewed. Finally, the characterization of the reliability of the method is discussed.

**SP619; 1982 March. 154-161. Fitz-Simons, T.; Beard, M. E. Simulation of the EPA provisional method for airborne asbestos concentrations.**

**Key words:** ambient air; asbestos; EPA provisional method; fibers; sampling errors.

The most expensive segment of the EPA provisional method for measuring asbestos in the ambient air and the segment that has the greatest potential for error is transmission electron microscopy. Consequently transmission electron microscope analysis is simulated. A hypothetical filter is loaded with fibers. The fiber lengths and widths are generated as a bivariate distribution. The location on the filter and orientation of the filter are generated as uniform random variables. The EPA provisional method is then followed to estimate fiber counts, mass, and size distribution. A plug is taken from the filter, a grid is defined, the grid openings are sampled according to the method. The simulation is presented graphically. Assumptions used in the simulation and the random and systematic sampling errors are discussed.

**SP619; 1982 March. 162-168. Steel, E. B.; Small, J. A.; Sheridan, P. Analytical errors in asbestos analysis by analytical electron microscopy.**

**Key words:** asbestos analysis; electron microscope; error; fibrils; laboratories.

Instrument and operator related error can combine to yield large inaccuracies in analyzing asbestos samples by the analytical electron microscope. Imaging, diffraction, and mechanical stage problems can yield cumulative errors causing results of the same area of a sample to vary by a factor of two or more. Operator precision and bias vary considerably. The five operators for which the data was collected have an average tendency to undercount by approximately 10 percent or greater in the samples investigated (loadings of 25-45 fibers per 200 mesh grid square, using NIEHS short fiber chrysotile). Most of this undercounting occurs in the short, single fibrils that are under  $0.4 \mu\text{m}$  in length. At or below this length our operators have approximately a 50 percent or less chance of detecting the fibers. Since our operators yield comparable results with other experienced laboratories, we expect that other operators are also missing small fibers.

**SP619; 1982 March. 169-182. Leigh, S.; Steel, E.; Small, J.; Sheridan, P.; Filliben, J. Statistical considerations in the preparation of chrysotile filter reference materials: Filter homogeneity.**

**Key words:** analysis; asbestos fibers; chrysotile filter; filter homogeneity; Poisson statistical process; statistical methods.

The data discussed shows that asbestos fibers can be deposited in a manner compatible with a Poisson statistical process when using careful liquid filtration onto Nuclepore filters and when using a fiber density of approximately 10-70 fibers per grid square. However, this hypothesis should be tested for each filter using methods similar to those described. The analysis also shows that such filters can be homogeneous enough to allow individual sections of a filter to be considered as representative of the whole filter sample.

Note: In order to adequately describe materials and experimental procedures, it was occasionally necessary to identify commercial products by manufacturer's name or label. In no instance does such identification imply endorsement by the National Bureau of Standards nor does it imply that the



particular product or equipment is necessarily the best available for that purpose.

**SP619;** 1982 March. 183-189. Yamate, G.; Beard, M. E. **Refinements in the EPA Provisional Methodology.**

**Key words:** asbestos minerals; electron microscopical method; environment; EPA Provisional Methodology; particle technologist.

Although the electron microscopical method is the best available to assess the asbestos minerals in the environment, the credibility of the analytical technique is weakened due to variations in the methodology with resulting diversity of data. The EPA Provisional Methodology on the electron microscope measurement of airborne asbestos concentrations was developed from a study under EPA Contract No. 68-02-2251 to evaluate the various electron microscopic methods to arrive at an optimum composite procedure. The lack of properly defined standard procedures restricted its acceptance as the *standard* analytical technique.

The present study under Contract No. 68-02-3266 investigated the problem areas of: (1) sample collection; (2) sample transport; (3) sample preparation procedures; (4) identification of particles as fibers; and (5) verification of asbestos materials. The critical parameters of which filter type (polycarbonate or cellulose ester type), transfer method, and fiber identification were also examined.

The expertise of the particle technologist and the electron microscopist have been combined to refine the EPA Provisional Methodology to obtain a more consistent analysis. Three levels of analytical sophistication are advocated.

**SP619;** 1982 March. 190-206. Ring, S.; Suchanek, R. J. **Fiber identification and blank contamination problems in the EPA Provisional Method for asbestos analysis.**

**Key words:** asbestos; asbestos minerals; chrysotile fiber; EPA provisional method; filter.

Two problems with the EPA provisional method for analysis of airborne asbestos by electron microscopy are identified. These problems are 1) an inadequate discussion of blank contamination problems and 2) fiber identification procedures that are not rigorous enough to prevent some minerals from being misidentified as asbestos. In order to illustrate the blank problem, the additive nature of chrysotile fiber contamination in the three stages of a cellulose acetate blank filter preparation procedure is demonstrated. Increases in fiber lengths and widths as well as numbers in successive preparation stages are shown to be statistically significant. Considerable variability was found in fiber numbers from filter to filter at each preparation stage. Metropolitan air sample chrysotile concentration and size data are compared with blank concentration and size data. The potential for confusing amphibole diffraction patterns with other minerals (including palygorskite, sepiolite, enstatite, hypersthene, magnetite, laumontite and minnesotaite) is discussed. A more rigorous procedure for identifying asbestos minerals, incorporating both energy dispersive x-ray analysis and tilting the fibers to obtain zone axis diffraction patterns is recommended.

**SP619;** 1982 March. 207-210. Clark, R. L. **MSHA standard method for fiber identification by electron microscopy.**

**Key words:** electron microscope; energy dispersive x-ray spectrometry; image analysis; scanning transmission; selected area electron diffraction; transmission electron microscope.

The EPA Provisional Methodology Manual represents an eclectic compendium of techniques employed in the analysis of airborne particulates for asbestos by electron microscopy. Philosophically, the methods tested and the resulting conclusions have a certain degree of universal applicability. In practice, however, absolute adherence to the method may not be possible due to differences in mandated standards, methods, and techniques.

The Mine Safety and Health Administration has developed a standard method for the analysis of airborne particulates which roughly parallels the EPA method. Variations in the technique include optical microscopy for fiber count, transmission electron

microscopy (TEM) for photomicroscopy and selected area electron diffraction (SAED), scanning transmission electron microscopy (STEM) for image analysis, and energy dispersive x-ray spectrometry (EDS) for elemental composition.

Applications of the technique as a routine analytical method will be discussed, with particular emphasis on areas of variation from the EPA method.

**SP621.** Shives, T. R.; Willard, W. A., eds. **Failure prevention in ground transportation systems.** Proceedings of the 31st Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards; 1980 April 22-24; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 621*; 1982 October. 223 p. SN003-003-02428-7.

**Key words:** bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems.

These proceedings consist of 18 submitted entries (16 papers and 2 abstracts) from the 31st meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards, Gaithersburg, Maryland, April 22-24, 1980. The theme of the symposium was failure prevention in ground transportation systems. Areas of interest included rail vehicles and structures, highway and road bridges, pipeline transportation systems, and motor carriers. *These proceedings include the following papers (indented):*

**SP621;** 1982 October. 3-17. Johnson, M. R. **Component reliability of railroad freight car trucks.**

**Key words:** derailments; fatigue; freight car truck; railroad accidents; railroad freight car; railroad testing; reliability.

The modern freight car truck is a relatively simple structure which provides for weight transfer between the car and track, maintains the proper positioning of the wheels with respect to the rail, contains the suspension elements for isolating the effects of wheel/rail forces and acts as a support for the brake. The number of freight car truck components which fail and cause accidents is low with respect to the number of cars in the railroad fleet. Continued efforts for their improvement are warranted because of the potential seriousness of accidents. Most freight car truck components function as safelife rather than fail-safe structures requiring a conservative approach to their design. The reliability problem is complicated by the practical difficulties of making adequate field inspections. Current efforts to improve reliability include gaining a better understanding of complex wheel failure phenomena, improving design and performance specifications, developing new systems for wayside inspection and developing new truck designs for the reduction of wheel/rail forces.

**SP621;** 1982 October. 18-32. Interrante, C. G. **Fracture of steel plate materials under abusive service conditions in railroad tank cars.**

**Key words:** fracture control; hazardous materials; impact transition; pressurized tank car; stress-rupture.

In recognition of the potential for catastrophic accidents involving railroad tank-car operations, the Federal Railroad Administration has actively participated in a continuing industry/government research program to enhance the safety of these operations. Selected parts of this program will be discussed with emphasis on the challenges presented by abusive service conditions that are associated with accidents, the ameliorative measures that have been taken to date, and the direction of the present work aimed at furnishing improved guidelines for fracture-safe design.

**SP621;** 1982 October. 33-45. Sharir, Y.; Stone, D. H.; Pellini, W. S. **Fracture analysis of cast steel components in rail vehicles.**

**Key words:** cast steels; fatigue crack growth rates; fracture analysis; mechanical testing; microstructure; rail vehicles; SEM fractography.

Couplers in rail vehicles made of AAR C-grade cast steel have been tested in the laboratory in simulated, full-scale fatigue tests.



Fracture analyses were carried out on broken components to characterize cause and mode of failure for comparison with field failures. The majority of the failures initiated at flaws on the surface, mainly casting defects, characterized to fall in the range of  $K_t=1.5$ . In the laboratory, cracks initiating at these flaws propagated in fatigue to the point where catastrophic failure occurred in a brittle mode. This fracture sequence is similar to that found in field failures. A metallurgical analysis which included microscopic examination as well as mechanical testing was carried out. Most of the failed components were composed of normalized steel with pearlitic structures having poor dynamic toughness and transition impact properties which are believed to be the major factors leading to failure.

**SP621; 1982 October. 49-68. Mirabella, J. V. Requirements for on-board failure detection systems for rail-vehicles.**

**Key words:** contact derailment sensor; g-sensing derailment detector; local derailment; nitinol sensor; on-board failure detection system; overheated bearings; thermal switch sensor; train line.

On-board failure detection systems for rail vehicles are proposed as a means of reducing train accidents particularly in the high speed range. In this paper, accidents are broken down in broad categories of cause and speed range. Special emphasis is given to equipment caused accidents as a percentage of total accidents for all speeds and then for 3 speed ranges—10 mph and below, 11 mph-30 mph, 31 mph and above. When the accidents occurring at speeds of 31 mph and above are isolated, equipment caused accidents represent a larger portion of the accidents than when the analysis includes the lower speeds. Isolating component failure accidents, a similar trend is noted with certain components causing a very small percentage of accidents at lower speeds, but causing an increased percentage of the accidents at higher speeds. These components are discussed in terms of past research with on-board sensors as well as possible candidates for future research and development. Various approaches are discussed to examine methods to use the sensors in a system for possible safety benefits. The advantages and disadvantages of each type of system are discussed.

**SP621; 1982 October. 69-90. Orringer, O.; Ceccon, H. L. Detection of rail defects and prevention of rail fracture.**

**Key words:** crack detection; inspection interval; rail flaw detection.

Rail transportation safety is maintained in part by periodically conducting a continuous search of track to find and correct rail defects. The state of the art of this detection technology is reviewed to illustrate, in general terms, the capabilities available to the railroads. A joint government/industry effort is now in progress to determine whether the periodic inspection strategy can be improved by means of an adaptive control algorithm that permits variation of the inspection interval based on actual histories of detected defects. The results of some preliminary studies are presented to illustrate how simulation techniques can be used to assess the effectiveness of proposed changes of inspection strategy.

**SP621; 1982 October. 91. Ferguson, J. D. Automated NDE for detection of braking abnormalities of trains.**

**Key words:** automated NDE; Braking Inspection System (BIS); braking system performance; trains.

Wayside instrumentation was designed, fabricated, and tested that demonstrates the feasibility of detecting braking system performance on moving rail cars. This instrumentation is being converted into a Braking Inspection System (BIS) prototype. The objective of the BIS is to provide a digitized output for braking alarm signals, wheel weight, wheel temperature and braking reaction force.

Currently, "braking" or "no-braking" conditions can be detected and presented in a digitized output. "Inadequate" or "excessive" braking is dependent on the actual braking force magnitude. Thus, efforts are underway to discriminate the discrete braking force from a measurement signal that includes a number of random forces not associated with the braking action.

**SP621; 1982 October. 95-109. Fisher, J. W.; Hausammann, H. Failure analysis of highway bridges.**

**Key words:** analysis; bridges; crack propagation; failure; fatigue; fracture; fracture surface; fracture toughness.

An evaluation of cracking that developed in two bridge structures is considered in the paper. Fatigue cracking was first observed at the Yellow Mill Pond Bridge on the Connecticut Turnpike (I-95) in 1970. Fatigue crack growth resulted in complete fracture of a tension flange in one of the girders. Smaller cracks were discovered in several other beams. Fatigue cracking started at the end weld of cover plates welded on the rolled section which forms the longitudinal girders of the bridge structure.

The results from the bridge observations are compared with laboratory fatigue test data on small size and full size covered beams. The laboratory tests and analytical predictions of crack growth agree well with the observations made on the Yellow Mill Pond Bridge.

A large crack was discovered in November 1973 in a fascia girder of the suspended span of the Quinnipiac River Bridge near New Haven, Connecticut. Crack propagation was found to occur in different stages. A detailed examination of the fracture is given in the paper. Fatigue cracks were found to originate at lack of fusion areas in horizontal stiffener splices. After the crack penetrated the web thickness it resulted in brittle fracture of the web. Crack instability developed when the stress intensity at the crack tip reached the material fracture toughness. The fracture toughness was estimated from J-integral measurements and from Charpy V-Notch test data.

**SP621; 1982 October. 110-129. Hanson, J. M. Failure analysis of Dan Ryan Rapid Transit structure.**

**Key words:** brittle fracture; failure; fatigue; rapid transit; steel frames; welding.

On January 4, 1978, major cracks were discovered in three adjacent rigid steel frames supporting an elevated curved section of the Dan Ryan Rapid Transit.

Visual inspection of the cracks and subsequent microscopic examination of the fracture surfaces established that the fractures started at the welded junction of the bottom flange of girders that pierced the side plates of the frame. Fatigue crack growth was found in the junctions. Quality of the welding was poor, partly as a result of the geometry in the joint. However, the notch from the rough flame-cut slot was determined to be sufficient to initiate the fatigue cracking.

Physical tests were made to determine the appropriate stress intensity factor for the steel. This testing verified that the critical combination of a severe defect, high stress concentration, and cold temperature was sufficient to cause the fractures.

**SP621; 1982 October. 130-142. Hartbower, C. E. Bridge welding and fracture control.**

**Key words:** fracture control; nondestructive inspection; quality control; welded steel bridges.

In the 1970's at least twenty bridge girders suffered brittle fracture and over a hundred girders were found to be cracked; fortunately (or providentially) there was no catastrophic collapse. However, with an apparently increasing incidence of weld cracking and fatigue cracking, the probability of a catastrophic collapse occurring in the 1980's is very real indeed.

The range of occurrence of weld cracking in steel bridges has reached alarming dimensions. Why? Is there a problem with the design of welded connections? Is there a shortage of qualified welding engineers? Is there a problem with quality control and quality assurance in fabrication? Is there a people problem and/or deficiencies in the flaw-detection techniques? Is there a need for nondestructive testing engineers? Is there a base-metal weldability problem? Is there a problem with cosmetic corrections and weld repairs? The answer is an emphatic yes to each of these problems and more!

The situation is so serious that without prompt positive action on the part of all concerned, there will be more and more bridges



made of concrete even where steel makes better engineering sense.

The paper takes a second look at some of the above problems using bridge failures from the 1970's as examples and then suggests some changes that will have to be made in the 1980's if the problems we now face are to be solved.

**SP621; 1982 October. 143-150. Bracher, D. A.; Garrett, D. A.; Heller, C. O. Theory and design of instrumentation for bridge investigation.**

**SP621; 1982 October. 153-164. Erdogan, F. Ductile fracture analysis of pipelines.**

**Key words:** crack initiation; crack opening displacement; ductile fracture; leak vs. break; part-through crack; pipeline fracture; plastic necking instability; progressive crack growth.

In this paper after briefly discussing the evolution fracture failure in pipelines and reviewing the related basic concepts, the problem of ductile fracture is considered. It is assumed that the thickness-to-radius ratio of the pipe is sufficiently small so that structurally the pipe may be treated as a cylindrical shell. It is also assumed that the pipe wall contains a part-through crack around which yielding takes place through the entire wall thickness. In the analysis the plastic deformations are approximated by a perfectly plastic layer and the bending theory of shallow shells is used to solve the problem. The questions regarding the fracture initiation along the crack front, the progressive growth of the crack, the plastic necking of the net ligament, and the pipe rupture leading to leak or break are then considered. The concept of crack opening stretch is used in the analysis and the discussion of ductile fracture.

**SP621; 1982 October. 165-173. Placious, R. C. Radiographic variables and weld flaw analysis.**

**Key words:** flaw analysis from radiographs; flaw depth determinations; pipeline radiographic inspection; radiographic nondestructive testing; weld flaw inspection.

An alternative to existing workmanship codes, where failure predictions are based on a priori experience, is a fitness-for-purpose criteria where failure predictions are based on fracture mechanics analysis. In this alternate "code," critical flaw dimensions form the coordinates for a decision curve separating failure-no failure regions. The critical flaw dimensions under this system are the length and through-the-wall depth of the flaw, at least for the particular case of pipeline girth welds. This requirement to accurately dimension flaws puts additional quality control on the radiographic inspection procedures. The flaw depth, in particular, cannot be directly determined by scaling the radiograph. We need to measure the image contrast presented by the flaw and relate this to metal thickness reductions. Contrast however, is considerably influenced by the radiographic variables. Some of these are under the radiographer's control; some are not. The variables over which some degree of control can be exercised include x-ray kilovoltage and filtration, film and screen selection, and film processing techniques. The variables over which the radiographer has little control are mainly of a geometric nature—that is, they are related to the exposure geometry. These include x-ray source size, source to film distance and material thickness for example. These geometric quantities also determine the radiographic definition or "unsharpness" of the image. The limits on accuracy of flaw depth analysis due to these variables will be analyzed in this paper.

**SP621; 1982 October. 174. Nakabayashi, M. Development of welding consumables for arctic pipelines.**

**Key words:** arctic pipelines; arc welding fluxes and wires; welding consumables; weld metal impact requirement.

In order to meet the severe requirements of Arctic pipe quality, a series of new submerged arc welding fluxes and wires were developed over the last several years for commercial line pipe production. Additional efforts are now underway at Linde's Materials Technology Laboratory to improve upon these new fluxes and wires.

The current specification calls for weld metal impact

requirement of 70 ft lbs at 0°F. In order to achieve this in practical commercial applications, pipe manufacturers are seeking weld metal impact values of the order of 80 to 85 ft lbs at 0°F. Such high impact properties of weld metal have to be met in multiple wire, high current, high speed submerged arc welding conditions which is typical of the current pipeline seam welding practice.

In order to attain such a goal it is imperative that control of weld metal microstructure (achieved by controlling heat input and chemical composition of weld metal) and substantial reduction of inclusion level in the weld metal are essential. Meeting the high weld metal impact property requirements is further complicated by high dilution from the base metal (60 to 70 percent is typical) which introduces some undesirable elements into the weld metal.

**SP621; 1982 October. 177-185. Pierson, K. L. 1978 roadside vehicle inspections.**

**Key words:** highway transportation; safety; vehicle inspections.

The safety inspection of vehicles and drivers, conducted during periods when actual highway transportation operations are underway, is one of the activities of the Federal Highway Administration's Bureau of Motor Carrier Safety intended to increase the safety of interstate commercial motor vehicle transportation on the Nation's highways. This report is a compilation of the results of the Bureau's roadside vehicle inspection activities conducted at various locations throughout the country during calendar year 1978.

**SP621; 1982 October. 186-195. Durham, R. V. Regulation, legislation and the teamsters—An equation for highway safety.**

**SP621; 1982 October. 196-200. Wulpi, D. J. Stress systems related to fracture of ductile and brittle materials.**

**Key words:** brittle materials; ductile materials; fatigue; fractures; machines; stress systems; tension loading.

**SP621; 1982 October. 201-211. Miles, V. H. Perspectives on diagnostic systems for the trucking industry.**

**Key words:** automated test equipment; diagnostics; technology in truck maintenance; truck maintenance aids.

The paper is based on a survey which was conducted among the members of the American Trucking Associations Maintenance Council. The primary purpose of the survey was to obtain an indication of how state of the art technology could be best applied to resolving the trucking industry's maintenance problems. Additionally, the survey was designed to assess the industry's receptiveness to new and sophisticated maintenance aids. This paper, therefore, presents a summary of the results of the survey and the conclusions we have drawn. The key point of the paper is that the maintenance of several vehicle systems such as electrical including the charging and starting system, engines, and brakes constitute a major cost factor to the industry. This cost can most likely be reduced significantly by the use of state of the art diagnostic systems. While the trucking industry appears to need this capability, it will be up to the manufacturers to develop the concepts and demonstrate their value.

**SP621; 1982 October. 212-214. Hellmuth, R. F. Investigation of defects in motor carrier activities.**

**Key words:** auto safety hotline; defects; motor vehicle equipment; motor vehicles; NHTSA; safety-related defects; safety standards.

**SP624. Dynamac Corporation. Proceedings of the National Water Conservation Conference on Publicly Supplied Potable Water. 1981 April 14-15; Denver, CO. Natl. Bur. Stand. (U.S.) Spec. Publ. 624; 1982 June. 467 p. Available from: NTIS; PB 82-234501.**

**Key words:** municipal water systems; potable water reduction; water conservation.

This "Proceedings" is a complete compilation of the papers presented April 14 and 15, 1981, at the National Water Conservation Conference—Publicly Supplied Potable Water in Denver, CO. The



Conference was primarily directed toward elected and administrative officials of local governments, the individuals who are responsible in some part for the quantity and quality of water available to their communities.

Techniques for, and analysis of, potable water conservation and wastewater flow reduction were presented. The topics addressed included: Water-Saving Technology: Plumbing fixtures, testing and performance of low-flow devices, leak detection and repair, potential problems in wastewater flow reduction, and landscaping with native vegetation. Public Education and Motivation. Economics: Water pricing systems, analysis of cost/benefits, and development and management of data. Planning: State and local urban planning efforts for conservation, and Federal programs and incentives. Case Studies: From California, Washington, Utah, Arizona, North Carolina, Maryland, New Jersey, and Massachusetts. *These proceedings include the following papers (indented):*

**SP624; 1982 June. 17-26. Walker, W. R. Water law: Impact on conservation.**

**Key words:** conservation; riparian doctrine; water law.

Laws with respect to water are unusual because they may vary depending on the form in which water is found. It is further complicated because the states do not have uniform laws for water in its various forms. Water with bed and bank in the western United States must conform to the prior appropriation doctrine which places emphasis on the protection of private property rights rather than maximum utilization. Water in this same form in the East is governed by the riparian doctrine which defines the water rights according to the place of use. Water under the ground may follow the English, American, or reasonable use rule. Diffused water which flows over the surface of the ground must be captured to establish a right. All of these laws evolved generally for historical reasons and have been modified slightly by statutes but not uniformly. None were designed to reduce consumption, promote efficiency or facilitate change to a higher beneficial use. The development of constitutionally protected water rights has made change more difficult. Yet these laws and the institutional structures which have evolved to implement them must be modified to promote greater use of a finite resource.

**SP624; 1982 June. 27-36. Nelson, J. O. Motivating the public to save water in the absence of a crisis.**

**Key words:** consumer education; drought-tolerant plant; water conservation.

Managing municipal water demands on a regular basis can be an important tool in helping to balance the supply-demand equation. Various elements or techniques can be considered by the utility, i.e., consumer education, pricing formulas, devices suitable for retrofitting existing homes, devices suitable for new development, irrigation equipment, drought-tolerant plant materials, and codes and regulations. But how do you successfully implement these elements and induce consumers to save water when there is no spectre of a water shortage to help congeal public action? In this paper the author shares his experiences in implementing water conservation in the North Marin County Water District and provides some tips and advice that have evolved from this experience. The thrust is a "volunteerism" type approach that first seeks a commitment from the consumer, followed by education and supply of materials, and lastly, follow-through surveys to determine the effective penetration of the idea or technique. Much of the advice developed by the author parallels empirically derived criteria employed by successful advertising agencies.

**SP624; 1982 June. 37-45. Preston, D. B. Providing section services in technical information and training.**

**Key words:** American Water Works Association; technical information programs; technical information retrieval.

The American Water Works Association's (AWWA's) training and technical information programs have been undergoing a major evolutionary change over the past several years. The planning, development, and implementation of various programs administered by the education department have been a time-

consuming process; currently, however, established programs are online and new directions are being examined to expand and improve member services.

What have been the primary causes that have brought about the dramatic changes in the Association's education services? Most visible has been the increase in staff from three to nine members in the past 5 years. The expansion of professional staff has been a building process of selecting persons with abilities in specialized areas of technical information retrieval, program coordination, and training materials development, who function as a team. The turning point, however, can be traced to two factors that have resulted in substantially changing the Association's posture and providing the impetus to move in new directions.

**SP624; 1982 June. 47-51. Wilborn, D. P. Water-saving plumbing: A flow control & maintenance program to reduce and control water use in multi-housing properties.**

**Key words:** control water flow; flow control devices; multi-housing properties; plumbing fixtures; water consumption; water-saving plumbing.

Evaluation of water consumption at multi-housing properties often reveals excessive and costly water use. The challenge to reduce and control water flow is being successfully met by a program designed to modify plumbing fixtures and provide management of water consumption.

**SP624; 1982 June. 53-59. Schmidt, N. M. Landscaping alternatives and irrigation conservation.**

**Key words:** faucet aerators; irrigation conservation; landscaping alternatives; water conservation; water-conserving devices.

I would like to make a few general comments concerning the subject of water conservation and what we in the home building industry are doing about that important subject. First, for the last 2 years the home building industry has been the recipient of a voluntary effort on behalf of the plumbing industry to provide water-conserving devices as standard equipment. New homes in Colorado have been receiving low-volume, 3-1/2-gallon toilets; low-volume showerheads; and faucet aerators. This is a dramatic case where voluntarism through private enterprise has moved at a faster pace than any government codes. Second, the trend toward smaller, more dense housing, which has primarily been motivated by issues of affordability, certainly has been a positive factor relative to water conservation. Outside irrigation demands are reduced by this trend toward more density. Third, I would hope that this audience would find the most recent National Association of Home Builders Consumer Survey very interesting. The historic main reasons for people buying new homes have been the need for moving to a larger home and moving to a nicer neighborhood. Energy has now become the number one subject of concern. Although the current main concern of energy is heating, the subject of water conservation also is included in the broad concern for energy-conserving homes.

**SP624; 1982 June. 61-66. Lyon, J. S. Water conservation: The leaks in implementation.**

**Key words:** conservation laws; Environmental Policy Institute; water conservation.

**SP624; 1982 June. 69-80. Yeaman, B.; Wesely, E. F., Jr. Developing and testing a water conservation handbook.**

**Key words:** Potomac River and Trails Council; Project Water Watch; wastewater treatment systems; water conservation.

How do we "sell" water conservation?

The advertising community would suggest that we begin by educating the residential consumer. "Easy Ways to Save Water, Money, and Energy at Home," a 32-page booklet produced by the Potomac River and Trails Council, was designed to do this.

What follows is the distillation of experience gained by the Environmental Protection Agency (EPA), which commissioned the booklet, and the Potomac River and Trails Council (PRTC), which designed and printed it.

We also describe "Project Water Watch," a program



undertaken by PRTC in Frederick, Maryland, a small but developing city of 30,000 where there is no perceived water supply problem. With a small EPA grant, PRTC has been testing the attitudes of local residents about water conservation, and about the booklet "Easy Ways to Save Water, Money, and Energy at Home."

**SP624;** 1982 June. 81-90. Postel, S. L. **Flow reduction: Methods, analysis procedures, examples.**

**Key words:** flow reduction; wastewater treatment.

Increasing numbers of communities across the nation are realizing the benefits of flow reduction in managing their wastewater treatment facilities. Among these benefits are savings in wastewater treatment, water supply and energy costs, as well as the ability to meet a greater portion of future needs with existing treatment capacity. *Flow Reduction: Methods, Analysis Procedures, Examples* (1) was prepared for the Environmental Protection Agency (EPA) to assist communities in developing cost-effective flow reduction programs. The manual's flexible, yet structured step-by-step procedure is a useful guide to developing program alternatives, analyzing program benefits and costs from a community viewpoint, providing for adequate public participation, and selecting a recommended program based on the analysis results. The manual also provides detailed information on flow reduction measures and specific devices, including their associated costs and water and energy savings, as well as examples of how to calculate a program's net monetary benefits. Two additional volumes will supplement Parts I and II of this manual. Part III will demonstrate the manual's procedure using two real-world communities; Part IV will provide additional guidance and material for developing flow reduction public information programs.

**SP624;** 1982 June. 91-102. Fisher, D. L.; Yost, J. A. **State water conservation planning guide.**

**Key words:** U.S. Water Resources Council; water conservation; water resource management.

The U.S. Water Resources Council, under the authority of Title III of the Water Resources Planning Act of 1965, provides grants to States for the development of comprehensive water and related land resources plans. Through the water policy initiatives of President Carter in 1978, agencies were directed to emphasize the integration of water conservation in the implementation of water resource management programs. Acting upon these initiatives and the directives of the President, the Water Resources Council emphasized the integration of water conservation in State programs.

To assist States in this endeavor, the Council developed the State Water Conservation Planning Guide. The planning guide is to be used primarily by State water planners in establishing and implementing a water conservation program. The guide details many of the necessary actions to implement an effective water conservation program. A prime objective of this guide is to bridge the gap that exists in many States between State and local water planning and implementation efforts. It is imperative that the participation and support of local utilities, municipalities, and other water purveyors be solicited during plan development and extended into implementation. The philosophy and objective of the planning guide, the proposed implementation guide, and the Water Resources Council grant program were always to extend Federal assistance, both technical and financial, down to the States, and through the States to local water purveyors. To accomplish more efficient water use, Federal efforts must be carried down to the local level.

**SP624;** 1982 June. 103-111. Sanders, W.; Thurow, C. **The role of land use planning in water conservation.**

**Key words:** land use planning; residential development; water conservation.

Land use planning and the regulatory controls that grow out of this process influence demand for water. Land development policies are formulated in the planning process and implemented through land use regulations. These regulations, especially zoning and subdivision controls, influence how much water a

municipality will need by regulating the types of buildings that are built, their location, and the way open space is used around them. This paper examines how this influence can be used to conserve water. Water conservation elements in comprehensive plans are considered along with patterns of development that conserve water. Land use regulations that can serve to implement water conserving residential development are also examined.

Land use planning can be important to water conservation. It can help conserve supplies or reduce demand. Traditionally, land use planners have not played a direct role in water supply planning, but for some time they have helped communities manage and protect watersheds or aquifer recharge zones that are threatened by urban growth. In recent years, a growing number of local planning agencies have recognized the potential for land use planning to reduce the need for urban water. Some communities are now including water conservation elements in their comprehensive plans, which identify both opportunities for water conservation and implementing strategies. A few communities have also built water conserving principles into their zoning and subdivision regulations.

**SP624;** 1982 June. 113-119. Rondon, J. **Aurora, Colorado: Rational landscape alternatives.**

**Key words:** water conservation program; water rights.

**SP624;** 1982 June. 123-133. Koyasako, J. S. **Water conservation and wastewater flow reduction—Is it worth it?**

**Key words:** wastewater flow reduction; water conservation.

This question was the subject of a recent research study largely funded by the Environmental Protection Agency (EPA). Two study reports were prepared: a detailed report published by EPA and a summary report published by the California Department of Water Resources. This study of indoor water conservation and resulting wastewater flow reduction arrived at one main conclusion: There are overwhelming benefits to be derived from community water conservation programs and they should be vigorously promoted.

**SP624;** 1982 June. 147-150. Knox, P. C. **Planning for the future.**

**Key words:** source of supply; water conservation; water use habit changes.

There is a long-standing base of environmental consciousness among the people of the Pacific Northwest. The conservation ethic is an important part of policies and actions affecting the region's resources. In 1975 a number of prestigious policy-making bodies and organizations strongly recommended water conservation as an alternative to development of new resources. The low rainfall of 1976-77 was the incentive to the Seattle Water Department to consider the conservation alternative. The Department examined the feasibility of the subject during the three ensuing normal years and, in 1980, the City adopted a Conservation Program. Without an impending disaster, the Program could assume a course based upon human value and rationality associated with future sources of supply. A cost/benefit analysis was conducted during the initial study for the Program based on an eight percent reduction in total demand to be reached over a ten-year period. The findings supported the adoption of the Program. The need to construct another source of supply will be delayed by six to seven years if the Program goal is reached. At the core of the Program are six voluntary cooperation projects and three public use management projects. Water customers were targeted and specific water use habit changes were identified to accomplish demand reductions through the projects. Program evaluation methods are being closely monitored by the City Council, which expects timely accomplishment of the projected reductions. Currently, the Office is involved in assessing evaluation in the light of staffing, methods and computer capabilities.

**SP624;** 1982 June. 151-154. Gillum, D. M. **Water conservation in Arizona: Past, present, and future.**

**Key words:** faucet aerators; flow reduction; groundwater law; public awareness; toilet dams; wastewater flow reduction; water conservation.



In the desert regions of Arizona and much of the Southwest, water is an extremely valuable commodity and should have the highest of priorities. Water conservation and good quality water are the key to our future and the future of our Nation. Arizona is currently involved in three water conservation programs. They are: 1) Beat the Peak and Slow the Flow, 2) Flow Reduction, and 3) A New Groundwater Law.

**SP624; 1982 June. 155-156. Linsky, H. S. Water conservation as a long-range supply option for Massachusetts: Dispelling the myths and facing reality.**

**Key words:** depletion of supply; myth of abundant water; quality degradation; water conservation.

The Metropolitan District Commission (MDC), serving Metropolitan Boston, is considering conservation as a long-term water supply option. The present MDC supply system has enormous storage capacity, however, and the impression of abundant water supply creates a situation quite different from the public perception of imminent shortages which characterize the national experience with water conservation.

A conceptual framework must be developed for converting national experience to realistic expectations for a long-range program in an area suffering from a myth of abundance but facing a gradual depletion of supply.

In order to include water conservation in long-range water supply plans we must scale down our expectations for potential demand reductions and be more realistic in our assessment of the costs and benefits of various programs.

**SP624; 1982 June. 169-171. Frank, A. Water conservation in rental apartment complexes by means of controlled installation of watersaving devices.**

**Key words:** controlled installation; leak detection; preventive maintenance; rental apartment complexes; waste flow; water conservation; watersaving devices.

Howard County, Maryland, in common with many other local jurisdictions, is experiencing rapid growth of its population and housing stock. As a result, it is expected that demand for water and sewer service will continue to increase, and that expansion of service into new areas will be necessary. In order to satisfy these needs, major new investment will be required. A primary strategy designed to offset the impact of this trend is reduction of per capita water use and waste flow.

The program which has been developed to implement the strategy will initially focus the County's efforts (to reduce water use and waste flow) on rental apartment complexes. It will be accomplished by employing a relatively unique concept: co-funded, controlled installation of watersaving devices concurrent with leak detection, repair, and preventive maintenance.

Howard County proposes that the development of a practical conservation program, based on controlled use of resources and corrective maintenance, will result in significant reductions of water (and energy) costs relative to investment, will enhance the state-of-the-art, and will provide a valuable case study for use by other jurisdictions.

**SP624; 1982 June. 173-177. Barnett, J. A. Enhanced water education versus status quo et al.**

**Key words:** water education; water education materials; water resource issues.

Water resource authorities, appointed by the governors of the twelve western states, determined six years ago that there was a significant need for better water education. These officials, members of the Western States Water Council, felt it was important for the public to be well informed on water resource issues as the nation moves ahead and faces many difficult water resource decisions. They determined that the Western States Water Council was not the appropriate vehicle for the preparation of these water education programs, and that the need for water education was not limited to the western United States. The Council instructed that a non-profit water education corporation be formed to pursue these most worthwhile

educational efforts.

Water & Man, Inc. is the new non-profit corporation fostered by the Council, and has been growing from a very humble beginning six years ago, through various stages of support, solicitation, fundraising, and the creation of water education materials. The Trustees of Water & Man have determined that their first effort would be to prepare and disseminate quality water education materials to be used in the public schools of the nation in grades K-12. Initial materials have been prepared and they are currently being disseminated to participating states.

**SP624; 1982 June. 179-190. Baumann, D. D. Information and consumer adoption of water conservation measures.**

**Key words:** public education programs; urban water resource planning; water conservation.

Educational campaigns concerning a specific issue are likely to fail unless they are based upon specific information about the recipients. There is some experience that some consumers respond to pleas for reducing water use during periods of shortage. However, during nondrought periods, more specific information is needed in order to design an effective water conservation program: it simply is not sufficient to assume that knowledge of water conservation measures will result in adoption.

**SP624; 1982 June. 193-196. Pabon, Sims, Smith, and Associates, Inc. Residential water conservation handbook.**

**Key words:** appliances; conservation programs; residential water conservation; water-saving plumbing devices.

This practical guide to residential water conservation entails the review and evaluation of water-saving plumbing devices, appliances, and techniques for their technical and economic feasibility, as well as their public acceptance and regional applicability. The resulting consumer handbook aimed at the homeowner was produced to help consumers conserve water. The handbook was market tested for content, theme, readability, language and style. A national information dissemination plan was researched to ensure widespread distribution of the handbook to targeted audiences.

**SP624; 1982 June. 197-206. Crews, J. E.; Schilling, K. E. A procedures manual for evaluating water conservation planning.**

**Key words:** groundwater resources; water conservation planning; water resource development; water resources.

In the past few years, the role of water conservation in the management and planning of water resources has become increasingly important. A number of factors account for this emphasis: (1) new reservoir sites have become increasingly scarce; (2) concern for environmental quality has grown; (3) groundwater resources are increasingly inadequate to meet the demands of urban areas; (4) political, economic, and institutional problems of interbasin transfers have proliferated, making it nearly impossible to plan for transfer of water from one basin to another; (5) the costs of water resource development have risen enormously in the last decade as a result of the increase in the price of energy, the increase in the cost of money, and the rise in water quality standards as manifested in the passage of Federal legislation such as the Federal Water Pollution Control Act Amendments (1972), the Safe Drinking Water Act of 1974, and the Clean Water Act of 1977; and (6) the demand for urban water has continued to increase. In combination, these factors have created a situation which directs attention to the possibilities of water conservation.

The Corps of Engineers recognized these trends and began policy studies and research early in 1978 to define and integrate water conservation into its Civil Works program. This paper presents one of the major outputs of this research effort and discusses how the Corps views water conservation.

**SP624; 1982 June. 207-209. Craft, G. L. AWWA water conservation handbook.**

**Key words:** American Water Works Association (AWWA);



conservation policy; water conservation.

**SP624; 1982 June. 211-223. Water Supply/Conservation Program Staff. *Before the Well Runs Dry: A handbook for designing a local water conservation plan.***

**Key words:** water conservation plan; water supply planners.

In February 1979, the New England River Basins Commission (NERBC) received funds from the U.S. Geological Survey (USGS), Resources and Land Investigations Program, to research and develop a planning procedure for water conservation. The project included an extensive literature search, development of local case studies, interviews with water supply engineers and policy makers, and an evaluation of the effectiveness of alternative water conservation measures. From the information it gathered and analyzed, NERBC developed a seven-step procedure for designing a local conservation plan. The sources for the procedure and the procedure itself are presented in a two-volume technical report, *Before the Well Runs Dry*.

In 1980, NERBC received additional funds from USGS's Water Resources Division to prepare a handbook for the practical application of the information contained in the technical report. The handbook is designed to provide a concise, clear-cut procedure for local water supply planners to follow in designing a conservation plan. The procedure outlined in the handbook has been reviewed by water supply engineers, administrators, superintendents, and planners throughout New England. It is flexible, can be used by any type of water utility, and can meet a variety of goals. This paper summarizes the information presented in the handbook.

**SP624; 1982 June. 227-238. Weber, S. F.; Lippiatt, B. C.; Hillstrom, A. P. *Cost-effective residential water conservation decisions.***

**Key words:** major costs; wastewater treatment; water conservation; water-saving devices.

An economic decision rule is presented for utilities to use in recommending water-saving devices that are cost effective for homeowners. The rule takes into account the major costs (acquisition, installation, operation, maintenance, repair, and replacement) and benefits (dollar savings on water, sewer, and energy bills) associated with the installation of water-saving devices. One of these benefits, the dollar value of water savings, depends critically on water prices. An analysis of the water rate schedules of a national sample of 90 utilities indicates that, because of the widespread use of large fixed and minimum charges, homeowners' actual benefits from saving a unit of water are significantly lower than the average price paid for water. Thus, estimated water bill reductions will frequently be overstated if calculated on the basis of average price. The decision rule allows one to select the economically optimal device from a set of mutually exclusive alternatives, or the economically optimal combination of compatible devices for all the plumbing services in the house. The paper concludes by describing an interactive computer program that performs all the calculations needed to implement the decision rule.

**SP624; 1982 June. 239-245. Clark, R. M.; Males, R. M.; Gates, W. E. *A water supply simulation model: Analyzing for the implications of conservation.***

**Key words:** analytical mathematical modeling; data base management; spatial economics; water conservation; water distribution systems; water supply simulation model.

Water conservation, as it relates to the operations of water supply systems, is not simply a problem of reducing user demand. Financing structures for water utilities are traditionally such that a reduction in demand may necessitate an increase in rates charged to the consumer, to avoid shortfalls in utility income for debt service and fixed operating expenses. In addition, a number of "beneficiaries" of the water supply system, such as those who enjoy fire protection, or those whose land is more attractive for development due to the availability of water, but who are not major consumptive users of water, tend not to bear the potential increased unit costs associated with user demand reduction.

The problem can be considered as one of spatial economics—water system customers of certain classes, located in portions of

the service area, subsidize other beneficiaries of the system in other classes and areas. The impact of demand reduction, coupled with the existing financial and revenue structure, can be expected to exacerbate the existing subsidizations of water system beneficiaries. The Drinking Water Research Division of USEPA has developed a systematic approach, organized as a set of computer programs, to assist analysts in examining problems of spatial economics and physical behavior of water distribution systems. The approach, known as the Water Supply Simulation Model (WSSM), consists of a data base describing the physical, economic, and spatial characteristics of the distribution system and program modules to: create and maintain the data base; display it graphically; perform hydraulic network, time of travel, and other physical analyses; and to perform economic allocations to develop spatial cost of service. The system is general-purpose in nature, and can easily be modified to suit the needs of a specific situation. Through combination of concepts of spatial analysis, spatial economics, data base management, and analytical mathematical modeling, the WSSM provides a powerful tool for examining the consequence of alternative policies related to water supply utilities. The structure of the WSSM, and sample applications, are described.

**SP624; 1982 June. 247-258. Hopp, W. J.; Darby, W. P. *Cost-effectiveness of potable water conservation—Multifaceted approach.***

**Key words:** household water conservation program; potable water conservation; wastewater treatment; wastewater treatment utilities; water supply utilities.

This study evaluates the cost-effectiveness of household water conservation measures in terms of overall economic efficiency as well as from the individual points of view of homeowners, representatives of municipal wastewater treatment utilities, and representatives of public water supply utilities. The analysis considers potential capital and operation and maintenance cost savings resulting from reduced volumes of drinking water subject to conventional, as well as conventional and granular activated carbon, treatment processes; reduced volumes of domestic wastewater subject to secondary treatment; and reduced domestic hot water use. Evaluation is carried out using a net present equivalent which considers the time value of money as well as the effects of inflation and real price escalation. Results indicate that a household water conservation program consisting of a toilet-tank dam insert and a simple shower flow restrictor is cost-effective from all points of view considered.

**SP624; 1982 June. 259-266. Betchart, W. B. *Municipal water conservation—A water project that pays for itself.***

**Key words:** benefits; costs; water conservation; water-related expenditures.

Municipal water conservation's direct economic impact is one of its most intriguing aspects. When analyzed and presented carefully, it is also one of water conservation's strongest selling points. This paper describes a structure utilized for analyzing municipal water conservation benefits and costs. The key to the structure is inclusion of all significant direct benefits and costs. Three examples of results from utilizing the analytical structure are then described.

**SP624; 1982 June. 273-280. Konen, T. P. *Performance requirements and test procedures for water closets.***

**Key words:** residential water use; sanitary performance; surface cleansing; test methods; volumetric efficiency; waste removal; water closets.

Stevens Institute of Technology has completed the development of requirements and procedures for evaluating the sanitary performance of water closets. This effort was undertaken in conjunction with the U.S. Department of Commerce—National Bureau of Standards and the U.S. Department of Housing and Urban Development. The overall objective of their program is to provide technology to achieve a significant reduction in residential water use.

The objective of our study was to develop test methods for use by industry, code groups, enforcement agencies and others to



determine the functional performance of water closets and thereby provide safe and efficient designs and installations. This activity has paralleled the development of the proposed revision to the American National Standard A112.19.2—Vitreous China Plumbing Fixtures. The opportunity to incorporate our findings into the product standard has added to the significance of this program.

A review of the present techniques found many of the major producers using test media spanning a wide range of size, form and density. Little information was found within the industry as to the characteristics of waste products; however, an electronic search of biology and medical journals produced several interesting studies which led to the selection of the test media. In addition to physical simulation, the media must lead to repeatable and discriminatory tests.

The primary characteristics of the water closets for which test methods and procedures were developed include: surface cleansing, waste removal, including solids and liquids, and volumetric efficiency. As a service to industry and the general public the Laboratory makes available a test kit which includes the media, instructions and data sheets.

**SP624; 1982 June. 281-288. Baker, L. K. Experiences and benefits of the application of minimum flow water conservation hardware.**

**Key words:** flow reduction; plumbing; water conservation; water fixtures; water heating facilities.

Minimum flow water conservation is achieved by using hardware and techniques specifically designed around minimizing consumption while maintaining the function, both physiological and aesthetic, of the use as opposed to modification of redesign of existing hardware and fixtures.

These techniques and hardware have been used to significantly reduce water and energy consumption and sewage treatment and disposal problems in both commercial and residential applications. This paper presents results of these applications with over an 80 percent reduction in water consumption in commercial and 60 percent in residential applications. Impacts on sewage systems have been observed and projected for both on-site and central systems. Reductions in plumbing and water heating facilities are also discussed.

The hardware discussed represents an 80 percent to 85 percent reduction when compared to conventional flow reduction techniques.

**SP624; 1982 June. 289-292. Holycross, F. R. Technical requirements for low-flow devices.**

**Key words:** appliances; fittings; fixtures; low flows; plumbing products.

There are many technical problems that we, manufacturers of plumbing products, are aware of. Low flows, pressure fluctuations, pressure regulation, solids transportation, ad infinitum. We, individually and collectively, have some answers to these problems. Some of these answers are available now, to put to use. However, there are some problems that cannot be answered because of the confusion in codes. Where a solution is good in one code area it may not apply in another area. The systems of today do not lend themselves to solutions based on new system types. We, P.M.I. and our individual companies, are ready to work toward the end of conserving water resources. We feel we have the knowledge from experience and the capabilities to contribute to the solution of "our" problem and should be in any and all discussions of the planning and resolutions of this gigantic and grave problem.

**SP624; 1982 June. 293-326. Galowin, L. S. A model for the transport mechanisms of solids in building pipe drains.**

**Key words:** building pipe drains; low water usage devices; pitch of the pipe; plumbing drainage system; plumbing fixtures; transport mechanisms; transport phenomena; wall friction.

The requirements for potable water conservation have resulted in the introduction of low water usage devices and plumbing fixtures in buildings. Reductions in the quantity of water discharged into the gravity drainage plumbing system can result in inadequate transport of wastes after entry into the drain pipes.

Currently, studies of the transient partially-filled pipe flow with solids in pitched horizontal drains include analytical modeling of the hydraulic/solids interactions and experiments to develop a data base for validation of design methods or empirical correlations applicable to pipe sizing methods for the plumbing drainage system. Initial results from the research on transport mechanisms for solids required for sweeping solids through pitched drain pipes are presented. The modeling parameters and test data for the flow characteristics, solid size, pipe diameter, and pitch of the pipes are discussed. The dependence of the transport phenomena on the depth of the wastewater stream, the length to diameter ratio of the solids, pitch of the pipe, and wall friction are identified as significant parameters. The computed results from the predictive model for the hydraulic forces are shown to be physically consistent.

**SP624; 1982 June. 329-337. Maddaus, W. O.; Rothenberg, J. H. Developing data for residential water savings.**

**Key words:** low-water-using bathroom fixtures; residential water savings; retrofitting; water conservation device.

Demonstration projects are being conducted for the U.S. Department of Housing and Urban Development (HUD) to document water savings in actual homes. Arrangements to conduct demonstration projects have been made with the City of Atlanta Bureau of Water, Denver Water Board, Los Angeles Department of Water and Power, and the Washington Suburban Sanitary Commission. Projects were selected on the basis of estimated water savings, need for field data, cost, and other factors.

The following demonstration projects were selected: studies of contemporary and advanced low-water-using bathroom fixtures; a study of water- and energy-efficient homes; the effect of retrofitting on hot water and energy use; the effect of metering; the effect of a pressure change; a nationwide leak detection survey; nationwide surveys of water-using fixture use and shower water use characteristics; and the long-term effectiveness of retrofitting in various cities. Each project involves a test group of dwelling units, equipped with the water conservation device, and a control group for comparison. Results will be published in 1982 and 1983.

**SP624; 1982 June. 339-346. Wilder, J. J. How to implement a water conservation program—The Denver experience.**

**SP624; 1982 June. 347-352. Smith, F. J. Management information systems for water resources.**

**SP624; 1982 June. 367-372. Jamieson, D. G.; Million, G. S. Comparison between water conservation practices in the United Kingdom and the United States.**

**Key words:** demand management; supply management; Thames Water Authority; United Kingdom; water conservation practices.

During recent years, there has been a growing awareness, on both sides of the Atlantic, for the need to conserve resources. In the specific case of water conservation, there has been little exchange of information and, as a result, ideas have largely developed independently. The purpose of this paper is to draw comparisons between conservation activities as practiced in Britain and in the United States. Its intention is to cover both aspects of water conservation; namely, demand management and supply management, with a view towards acquainting the readership with British practices as adopted by the Thames Water Authority, and to suggest reasons for the differences between the United Kingdom and the United States in terms of attitude, emphasis, and outcome.

Obviously, any comparison of this nature is bound to be superficial; in this particular instance, the tenuity is compounded by our limited knowledge of American culture and practices. Nevertheless, the apparent difference in terms of per capita consumption is so marked that the lack of precise detail should be incidental.

**SP624; 1982 June. 373-378. Seinwill, G. D. Federal Water Resource Agency planning requirements and implications for water conservation.**



**Key words:** Federal Water Resource Agency; water conservation; water planning.

The 1978 executive water policy reform message was not a radical departure from earlier policy directives. However, its specificity about the role of conservation in water planning and management, its applicability to wider ranges of water activities, and its urgency for immediate response have differed from previous water policy statements.

**SP624; 1982 June. 379-397. Galowin, L. S. Plumbing codes—Essential in water conservation programs.**

**Key words:** plumbing codes; plumbing fixtures; wastewater flows; water conservation.

The development and implementation of water conservation programs requires acceptance of low water usage plumbing fixtures and devices. The installation of innovative components or modifications to existing plumbing systems for reduced water consumption are controlled by local jurisdictions through the plumbing codes.

A review of the developments leading to current plumbing code requirements is presented. The basis for development of revisions to codes and supporting standards from current research projects is discussed. Requirements are indicated for (a) current data based upon real water demand loads to update water supply pipe sizing (Hunter's Curve) and (b) the necessity to consider the impact of deterioration of performance from reduced wastewater flows in the building drainage system with expanding water conservation practices. Examples of laboratory research and field demonstrations of water conservation programs are provided.

**SP624; 1982 June. 401-407. Robie, R. B. Water conservation in California.**

**Key words:** in-school education; residential water conservation devices; water conservation; water resources planning; water system leak detection.

California's resource planning includes water conservation as a source of supply. By the year 2000, the State expects water savings of about 1.5 million cubic dekameters per year. Department of Water Resources (DWR) conservation activities are centralized in its Office of Water Conservation (OWC). Programs are in three major categories—agricultural, urban, and in-school education. The largest urban program is distribution of residential water conservation devices. By the end of 1982 all those living in homes built before water conserving fixtures became mandatory will be given devices. The Department works with other state agencies to save water, develops water conserving landscape gardens, encourages water conserving pricing, has a grant program for water system leak detection and works to build water conservation into local planning. Elementary school programs train teachers and make curriculum materials available. Education activities include a newsletter, drought and water conservation related reports and brochures. The Department reports on comparative water conservation performances of selected communities in the State.

Water conservation has been made an integral and vital element of water resources planning by the State of California. We see it as our most economical source of additional supply, and one that almost invariably results in savings of energy.

**SP624; 1982 June. 409-412. McArdle, F. X. The need for a new federal water policy.**

**Key words:** conservation management; federal water policy.

**SP624; 1982 June. 413-417. Miller, W. H. Local response for officials and consumers.**

**SP624; 1982 June. 421-425. Gilbert, J. B. A future look—What are the unknowns?**

**SP624; 1982 June. 427-432. Brusnighan, J. M. Appraisal of 1978 conference case history: Do the benefits endure?**

**SP624; 1982 June. 433-441. Neely, L. M.; Opaleski, M. J.;**

**Shelton, T. B.; Palmini, D. Conservation in a noncrisis environment—Township of East Brunswick, New Jersey.**

**SP624; 1982 June. 443-447. Butterfield, S. Case study—In-school water conservation education program.**

**Key words:** conservation program; water conservation education program.

California's in-school water awareness and conservation program for kindergarten through eighth grade students offers special curriculum materials and teacher training. Children are the greatest resource of the future and must learn to be wise consumers and citizens in order to make informed decisions when adults. The program teaches water's vital role in life, and that this resource is limited. A secondary benefit occurs when children carry water conservation messages home. Materials are available for the entire kindergarten through eighth grade spectrum, and as a result of evaluations, 4-6 grade materials are now emphasized. The program is continuous, not just a one-time informational campaign. With a small budget and staff, 10 percent of the total elementary grade population has been reached in the last three years.

One of our most successful water conservation programs and the one that has been around the longest is our in-school education program. It is a water awareness and conservation program for kindergarten through eighth grade students throughout the State that offers curriculum materials and teacher training.

**SP624; 1982 June. 449-452. Butterfield, S. Case study—Distribution of residential water saving devices.**

**Key words:** device installation programs; in-school education programs; residential water savings devices.

A state-wide program of distributing water conservation devices to residents of the State is to be completed by 1983, and to result in annual savings of about 58,000 acre-feet of water and the energy equivalent of 1.3 million barrels of oil. Savings pay for program costs in about three months. Distribution programs began in 1977 with pilot studies resulting in the present program configuration that is based on mass mailing of kits containing displacement bags and shower flow restrictors. All programs are cooperative with local agencies and tailored to local situations, and are accompanied by an advertising campaign and in-school education programs. Detailed reports on past programs are available.

**SP624; 1982 June. 453-464. Cronk, G. E. Results of a peak management plan for Tucson, Arizona.**

**Key words:** peak management; water use patterns.

Prior to the summer of 1974, the prevailing water service philosophy of the Tucson Water Utility had been to anticipate, and meet, the unmanaged peak demand requirements of the system by increased capital expenditures for expansion of the water system. The peak demand period of the summer of 1974, however, proved to be one of the driest and hottest periods on record in Tucson. The City well system proved to be incapable of consistently meeting the prolonged peak periods. This resulted in localized disruptions in service and chronic low pressures throughout the system. The experience of that summer convinced the staff of Tucson Water and their engineering consultants of the need to evaluate and reassess the original service philosophy regarding meeting future unmanaged peak demand requirements.

**SP624; 1982 June. 465-469. Rubin, A. R. Water conservation efforts in rural areas.**

**Key words:** agricultural water uses; demand reduction; drought emergency plans; educational programs; rural areas; water conservation.

North Carolina is predominantly a rural State. Recent census figures indicate that the rural counties in the eastern and western parts are growing at a more rapid rate than are the more urbanized counties in the central part of the State. Nonetheless,



major population centers do lie along the interstate highway routes that link Charlotte in the west with the Raleigh-Durham area in the east. Almost half of the State's population reside in this area known as the Piedmont Crescent. Historically, the water resources base that supports these areas has been adequate; however, with increasing population pressures, rapid industrial development, concomitant industrial development pressures, agricultural water uses, and commercial uses of water, the future availability of these once plentiful water resources is now being questioned. Many of the large urban areas are engaged in some form of water conservation program that has two primary aims: raising the level of consciousness and awareness of the local residents regarding potential drought emergency plans, and focusing on a series of educational programs, mailings, slide tapes, public meetings, exhibits, etc., on routine residential, commercial, industrial, and institutional demand reduction.

**SP624;** 1982 June. 471-477. Kinghorn, G. H. **Water conservation/flow reduction in facilities planning for Salt Lake County.**

**Key words:** flow reductions; water conservation.

**SP626.** Hoppes, D. D.; Schima, F. J., eds. **Nuclear data for the efficiency calibration of germanium spectrometer systems: Measurements from the laboratories of the International Committee for Radionuclide Metrology  $\alpha$ -,  $\beta$ -, and  $\gamma$ -ray spectrometry group.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 626;* 1982 January. 151 p. Available from: NTIS; PB 82-163882.

**Key words:** compilation; efficiency data; half lives; measurement uncertainties; photon probabilities per decay; relative photon-emission probabilities.

Members of the Alpha-, Beta-, and Gamma-Ray Spectrometry Group of the International Committee for Radionuclide Metrology agreed in 1979 to collect the nuclear data from any measurements in their laboratories that were pertinent to the calibration of the efficiency of germanium spectrometer systems. This report is composed of the contributions from 14 laboratories, as listed in part II. If a self-contained contribution was received, it has been incorporated without editing. Less formal communications, or references to published articles, are discussed in short comments prepared by the compilers. Part IV is a compilation of a selected portion of the data, arranged by radionuclide.

**SP627.** Johnson, D. R., ed. **Science and technology: The challenges of the future.** *Proceedings of the NBS 80th Anniversary Colloquium Series;* 1981 February-March. *Natl. Bur. Stand. (U.S.) Spec. Publ. 627;* 1982 May. 85 p. SN003-003-02396-5.

**Key words:** fundamental research; Government-industry relationships; industrial technology; NBS 80th Anniversary; productivity; science; software edge.

Challenges to science and technology in the 1980's are discussed in a series of six lectures by distinguished speakers of national and international reputation. In the first lecture, Dr. Lewis Branscomb, Vice President and Chief Scientist of IBM, discusses the roles of the Department of Commerce and the National Science Foundation in the future. Dr. Branscomb draws heavily on the experiences of the Japanese industrial community. Mr. William Carey, Executive Officer, AAAS, follows with his views on the interrelationships between Government, science and the society in the 80's. Carey emphasizes that science will play a key role in the future and that the scientific community must not be passive, but rather must accept responsibility for the impact its technology will produce. Dr. Arthur Bueche, Senior Vice President, General Electric Company, focuses specifically on Government-Industry relationships in the 1980s. A hypothetical "earthworm crisis" is used by Bueche to illustrate his view of the future. In the next lecture Dr. Arno Penzias of Bell Laboratories shares his thoughts and ideas about managing research in a changing environment. Penzias emphasizes selection of the right people and providing them with an environment to succeed. Mr. William Miller, President and Chief Executive Officer of SRI International, then discusses the national technological edge that the United States possesses in computer software. He traces software development in the United States and discusses our ability to capitalize on this technological advantage in the future. In the last lecture, Professor Richard Nelson of Yale University relates

technological advantages to productivity and growth from an economical point of view. Professor Nelson delineates a sharply defined and rather narrow role for Government in industrial research and development. *These proceedings include the following papers (indented):*

**SP627;** 1982 May. 1-15. Branscomb, L. M. **The competitive challenge to U.S. industrial technology R&D responsibilities of Government agencies, universities, and industry.**

**SP627;** 1982 May. 17-25. Carey, W. D. **Government, science, and society in the 80s.**

**SP627;** 1982 May. 27-41. Bueche, A. M. **Government-industry relationships in the 1980s.**

**SP627;** 1982 May. 43-49. Penzias, A. A. **Managing research in a changing environment.**

**SP627;** 1982 May. 51-67. Miller, W. F. **The software edge.**

**SP627;** 1982 May. 69-79. Nelson, R. R. **Technological advance and productivity growth: The roles of business and Government.**

**SP628.** McKnight, R. H.; Hebner, R. E., Jr., eds. **Measurement of electrical quantities in pulse power systems.** *Proceedings of the Workshop on Measurement of Electrical Quantities in Pulse Power Systems held at the National Bureau of Standards;* 1981 March 2-4; Boulder, CO. *Natl. Bur. Stand. (U.S.) Spec. Publ. 628;* 1982 June. 420 p. SN003-003-02403-1.

**Key words:** current measurement; electrical measurements; electromagnetic pulse; fusion; nuclear effects simulation; particle beam technology; pulse power; transients; voltage measurements.

The Workshop on Measurement of Electrical Quantities in Pulse Power Systems addressed measurements in pulse systems having the characteristics of pulse duration less than a millisecond, system voltages greater than 10 kilovolts, and system currents greater than 10 kiloamperes. The presented papers were divided into four categories: voltage measurements; current measurements; power and energy measurements, and data acquisition. Included are discussions of applications of conventional measurement techniques and state-of-the-art systems. *These proceedings include the following papers (indented):*

**SP628;** 1982 June. 1-19. Thompson, J. E. **Electro-optical pulsed voltage measurements.**

**Key words:** accuracy; calibration; electro-optical measurements; frequency response; interferometric measurements; Kerr effect; Pockels effect; polarization.

Pulsed voltages are typically measured using resistive or capacitive voltage dividers. Problems associated with these types of measurements include the effects of stray capacitance, oscillations, noise pickup, and ground loops. Many of these problems can be reduced and measurement frequency response improved by using electro-optical measurement techniques. The most useful optical techniques for voltage measurement are the Kerr and Pockels effects. The relevant characteristics of these two effects are discussed together with optical techniques useful for utilizing the Kerr effect to measure pulsed voltages. Frequency response, accuracy and calibration of the measurement techniques are discussed in the context of high voltage measurements. Specific electro-optical measurement techniques and devices including cross polarizer analyzers, interferometric measurements, matched impedance Kerr cells, a sampling transient analyzer, and a traveling wave measurement technique are discussed.

**SP628;** 1982 June. 20-25. Harris, N. W. **High voltage probe for liquid immersion.**

**Key words:** capacity divider; high voltage divider; pulse voltage monitor; voltage monitor; waterline voltage monitor.

A capacitive voltage divider for the measurement of very high voltage transients in liquid-filled transmission lines has been developed. The probe is suitable for pulse lengths in the range 10 nsec to 1  $\mu$ sec, and peak voltages between 50 kV and 10 MV. The divider automatically compensates for changes in dielectric



constant and loss.

**SP628; 1982 June. 26-33. Hebner, R. E. Experimental comparison of step-response and ramp-response measurements in freestanding dividers.**

**Key words:** divider; high voltage measurements; impulse; step response.

It is conventionally assumed that the magnitude and the waveshape of a high voltage pulse can be determined from measurements of the divider ratio, the step response, and the output voltage. This assumption has been verified experimentally by measuring the input with a second, reference divider which introduces negligible distortion in the applied waveform. The validity of the approach had been demonstrated for pulses ranging from less than a kilovolt to more than a megavolt on microsecond time scales. Specifically, in a system designed to measure pulses with peak values up to 4 MV, the differences between the calculated and measured voltages were typically less than three percent. The testing of the reference divider, the step response measurements, the data analysis and the high voltage testing of the system are described.

**SP628; 1982 June. 34-45. McComb, T. R.; Collins, M. M. C.; Sarjeant, W. J. A comparison of three different designs of resistor divider.**

**Key words:** comparative measurements; design; dividers; impulse measuring systems; resistor dividers; response time; voltage measurement.

This paper describes a comparison of dividers developed in the Laser Physics Section at NRCC with dividers developed in the Power Engineering Section, NRCC. Requirements on the design of high voltage impulse measuring systems, which are to be used to measure short-duration impulse voltages, are discussed briefly using transmission line concepts. Developments in the field of Power Engineering are summarized and the classification of impulse measuring systems into two-component and three-component systems is outlined. Four different dividers, whose response times lie in the range 1.4–15 ns, are described. Comparative measurements of the crest value of linearly-rising impulses chopped on the front have been made at a single voltage; these measurements have been corrected for the effects of system response time. Measurements of the crest value of a trapezoidal pulse have been made using three of these dividers and the results are presented in the form of a calibration curve covering the range 100–400 kV. Estimates of the correction needed to allow for the dividers' response times are calculated on the basis of rectilinear approximations to the trapezoidal pulse.

**SP628; 1982 June. 46-53. Power, J.; Nunnally, W.; Young, D. A 100-kV, 2-ns risetime, dc-coupled probe.**

**Key words:** dc-coupled probe; 2-ns risetime; 100-kV rating.

A high-voltage probe has been designed and constructed; it is unique because it may be used for both high-voltage dc and for transient measurements. The probe is rated at 100-kV dc with a short transient rating of 150-kV peak. System risetime is less than 2 ns. The input impedance is 1000 M $\Omega$  shunted by 13 pF. A distributed RC network providing the desired attenuation is housed in a 25.4-cm-diam cylindrical housing. A 15.2-m length of coaxial cable connects the probe to a termination network at the oscilloscope input. The oscilloscope input impedance must be at least 100 k $\Omega$  to maintain the correct dc attenuation ratio.

**SP628; 1982 June. 59-68. Wilkinson, M.; Chu, E. Calibration of capacitive voltage probes in water-dielectric, high power pulse generators.**

**Key words:** calibrations; capacitance-current; dielectric; high voltage pulser; pulse generators; voltage probes.

Capacitive voltage probes are frequently used in the water pulse-lines of high power pulse generators. These usually consist of small electrodes isolated from the outer conductor of the pulseline. The capacitance between the electrode and the inner conductor determines the output of the probe.

Due to finite resistivity of the water dielectric, a fast, high

voltage pulser is usually required to calibrate these probes. We will discuss a method, which we call the "capacitance-current" method, that allows probe calibrations with a slow pulser independent of the resistivity of water. We will compare calibrations obtained using this method against those obtained using more conventional methods.

**SP628; 1982 June. 69-79. Fujimoto, N.; Boggs, S. A.; Madge, R. C. Measurement of transient potentials in coaxial transmission lines using coaxial dividers.**

**Key words:** high voltage dividers; partial discharge; transient phenomena.

Techniques employing coaxial dividers, with flat response from the kHz region to >1 GHz, have been developed for measurement of transient phenomena in coaxial transmission lines. These have been used to investigate partial discharge induced phenomena in gas-insulated transmission lines as part of a program to develop incipient fault detection and location techniques for gas-insulated switchgear. This paper describes the basic application, the theory and practice of coaxial couplers, and examples of partial discharge-induced transients.

**SP628; 1982 June. 80-86. Stinnett, R. W. A voltage monitor for magnetically insulated transmission lines.**

**Key words:** insulated transmission lines; magnetic insulation; multiterawatt accelerators; particle beam fusion; peak gap voltage; voltage monitor.

Magnetically insulated transmission lines pose special problems in voltage measurement because of the extremely high electrical stresses that are typical in them and because of the initial electron loss which is intrinsic to the establishment of magnetic insulation. This new voltage monitoring technique uses negative ions which have been recently discovered in magnetically insulated transmission lines. These negative ions are produced in the cathode plasma and are accelerated by the gap voltage toward the anode. If two positively biased collectors are placed at different distances behind a hole in the anode, these negative ions may be collected to give time resolved signals which will provide the data necessary for a time of flight unfold of the gap voltage. A small magnetic field applied to the flight path can be used to deflect any electrons produced in the gap while not significantly deflecting the much heavier negative ion.

Although a complete voltage unfold may be difficult in practice, this technique may be used to obtain peak gap voltage very simply. If the collectors are located far enough away from the source, then the first negative ions to arrive will be those with the highest velocity, hence those produced at peak gap voltage. The velocity, and energy of these negative ions may be obtained to a few percent accuracy from arrival times at the two collectors.

**SP628; 1982 June. 87-94. Stanley, T. D.; Stinnett, R. W. Measurement of magnetically insulated line voltage using a Thomson Parabola charged particle analyser.**

**Key words:** magnetic insulating voltage measurement; negative ions; Thomson Parabola charged particle analyser.

The absence of direct measurements of magnetically insulated line voltage necessitated reliance on inferred voltages based on theoretical calculation and current measurements. This paper presents some of the first direct measurements of magnetically insulated transmission line peak voltages. These measurements were made on the Sandia National Laboratories HydraMITE facility.

The peak voltage is measured by observing the energy of negative ions produced at the line cathode and accelerated through the line voltage. The ion energy and the charge-to-mass ratio are measured using the Thomson Parabola mass spectrometry technique. This technique used parallel E and B fields to deflect the ions. The deflected ions are detected using a microchannel plate coupled to a phosphor screen and photographic film.

The Thomson Parabola results are compared to Faraday Cup measurements and to calculated voltages based on current measurements. In addition, the significance of observed positive



ions will be discussed.

**SP628; 1982 June. 104-117. Young, F. C. Ion current and voltage determinations by nuclear techniques.**

**Key words:** deuteron current; dielectric; neutron; proton current; pulsed generators; pulsed power; voltage determinations.

Nuclear reactions induced by intense proton or deuteron beams from high-power pulsed generators can be used for current and voltage determinations. Average currents and voltages are determined from measurements of delayed radioactivity from nuclear reactions. This technique is illustrated for proton current using the  $^{12}\text{C}(\text{p},\gamma)^{13}\text{N}$  reaction and for deuteron current and energy using the  $^{12}\text{C}(\text{d},\text{n})^{13}\text{N}$  and  $^{27}\text{Al}(\text{d},\text{p})^{28}\text{Al}$  reactions. Time-resolved current and voltage determinations can be made from measurements of prompt nuclear radiations. Proton currents are determined by prompt-gamma measurements using the  $^{19}\text{F}(\text{p},\alpha\gamma)^{16}\text{O}$  reaction. Neutron time-of-flight techniques are described to determine either the deuteron energy or current using the  $\text{d}(\text{d},\text{n})^3\text{He}$  reaction.

**SP628; 1982 June. 118-132. Nolting, E.; Martin, R.; Ruppalt, M. Electrical measurement techniques used at the Casino Facility.**

**Key words:** bremsstrahlung radiation; Casino Facility; effects simulator; nuclear weapons.

The Casino Facility is a Defense Nuclear Agency nuclear weapons effects simulator. The machine consists of four-one megavolt field-emission diodes each capable of producing a one-half terawatt power pulse. The diodes are located on the end of four separate, 4 MV water-dielectric coaxial lines and can be energized singularly or in combination. Each diode has its own set of diagnostic monitors. Transient diagnostics include voltage monitors, on the pulse-forming lines adjacent to the vacuum diodes and current sensors, on each of the diodes. Normal shot-to-shot variation in the Casino output necessitates accurate measurement of voltage and current with computer aided data reduction to determine diode performance. This paper describes the relevant features of the hardware and software used in the Casino digital data acquisition system. Techniques used to calibrate the various diagnostic monitors are presented including a discussion of the procedure used to time phase the current and voltage signals. This is followed by a comparison of the calculated delivered energy with total absorbing electron beam calorimeter measurements.

**SP628; 1982 June. 133-149. Hill, R. A. Indirect measurement by computer simulation.**

**Key words:** computer simulation; mathematical modeling; pulse circuits.

Enhanced instrumentation by means of computer aided techniques is particularly useful for measurements of fast, high energy electrical transients. An overview presented in this paper offers a general approach to making indirect measurements by mathematical modeling. The illustrative examples are taken from case histories of simulating the dynamic behavior of pulse circuits. Various examples described herein were selected to indicate a wide range of usage. These examples are given without the intent of rigorous analysis or rigid procedure. The purpose is to give discussion in appropriate workshop style.

Mathematical modeling is particularly useful in design and development of high power, complex systems because of necessary time and resources that must be committed for actual construction. The model can serve a variety of purposes for analysis of the equipment. A single, all purpose model would be too unwieldy for practical purposes; therefore, the model generally consists of a series of special purpose models, or related mathematical equations which describe a limited function. Solution to the descriptive equations may be determined by computer programs with suitable output display. Some models which may be adaptable for indirect measurements and estimating are discussed in the following sections.

**SP628; 1982 June. 150-164. Richardson, R.; Chu, E.; Clark, W.; Shannon, J.; Wilkinson, M. Calibration of the BLACKJACK 5 pulse generator output power.**

**Key words:** BLACKJACK 5 pulse generator; calibration procedures; calibration pulser.

A discussion will be presented of the calibration techniques routinely used to ensure precise measurement of output power from the BLACKJACK 5 pulse generator. Because of the high voltages ( $\sim 3$  MV) and high currents ( $\sim 5$  MA) which must be measured during normal operation, probes with very low absolute sensitivity are used. Calibration procedures will be described which consist of applying voltages and currents of sufficient levels to overcome the low sensitivity and provide good signal-to-noise ratios. The calibration pulsers are also designed with outputs having dominant frequency components close to the measure signals. Cavity type B current monitors are calibrated *in situ* and corrected for wall effects. These monitors are also checked against B loops. E type diode voltage monitors are also calibrated *in situ* by measuring the probe capacitance and by direct comparison with a voltage divider. Careful attention is paid to the frequency response of passive RC integrators used in the calibrations and final measurements. All cable lengths are trimmed to ensure precise phasing of the signals, and FFT techniques are used to correct for cable attenuation.

**SP628; 1982 June. 175-193. Di Capua, M. S. Rogowski coils, fluxmeters, and resistors for pulsed current measurements.**

**Key words:** current sensors; fluxmeters; pulsed current measurements; Rogowski coils.

This paper discusses the frequency response of current sensors for pulsed current measurements and sources of error measurement in these sensors. We examine the operating principles of Rogowski coils and fluxmeters from a lumped parameter as well as a transmission line viewpoint. This second, less conventional approach, is necessary when transit times in the sensor are comparable to the time resolution of the measuring circuit. Our discussion of current viewing resistors (shunts) emphasizes the transient behavior associated with diffusion of magnetic field in the sensor, and the limitations on the sensor imposed by Joule heating.

The choice of measurement method, based on the above analysis, will depend on the frequency, amplitude, distribution of current, as well as on the sensitivity and bandwidth of the recording device.

**SP628; 1982 June. 194-203. Wilmer, M. E.; Pearson, P. A. Precise measurement of current in pulsed power systems.**

**Key words:** current measurement; current monitor; current transformer.

In order to precisely measure currents in a pulsed power system, the capabilities and limitations of the instrumentation used must be well characterized. In this presentation, we shall examine the theoretical and empirical properties of internally terminated current monitors in pulsed power applications. The advantages of current monitors over current viewing resistors will be discussed. The factors affecting the inherent accuracy of current monitors will be analyzed and their temperature dependence reported. The effect of the current monitor on the circuit being measured will be examined and the insertion inductance and insertion resistance will be calculated as a function of the key current monitor design parameters. The voltage standoff characteristic of these monitors will be derived and the results tabulated for several clearance hole sizes both in air and in transformer oil. Core saturation will be related to the design parameters of the individual current monitors and its effect on the output waveform will be examined. The talk will conclude with an explanation of the usefulness of dc biasing in extending the range of current monitors, particularly those employing high permeability cores.

**SP628; 1982 June. 204-216. Praeg, W. F. Low-inductance shunts for measuring large pulsed currents.**

**Key words:** current transformers; precision shunts; pulsed currents; Zero Gradient Synchrotron.



Precision shunts have been developed at Argonne National Laboratory (ANL) to measure pulsed currents. Direct-coupled air- or water-cooled coaxial shunts have been built for a frequency response up to 100 kHz and with an rms current rating of up to 10 kA. Smaller shunts were designed to terminate current transformers for measuring  $<300$  kA pulses of 50 to 3000  $\mu$ s duration. Some of our applications require the shunt resistance to be repeatable within  $\pm 0.005\%$ . This made it necessary for us to determine the resistance-stress coefficients of manganin and to design the shunts for minimum stress. Stress in the manganin is caused by thermal expansion, by cooling-water pressure, by mounting arrangements, and by magnetic fields. Design details and performance data are presented.

**SP628;** 1982 June. 217-232. Muehlenweg, C. A.; McDuff, G. Measuring fast pulse current using low inductance current viewing resistors and di/dt probes.

**Key words:** current measurement; current viewing resistors; pulse current.

The ever increasing use of thyratrons and stripline pulse forming networks (PFN) in pulsed circuits has created a need for an accurate, low noise, extremely low inductance, wide bandpass method of current measurement. Recently designed Current Viewing Resistors (CVR) meet and surpass most of the requirements. Quality diagnostics are essential in the development of high efficiency, low loss, pulsed accelerators and a variety of other pulsed powered circuits.

Research and development in the area of current measurements for specialized requirements has been in progress for at least two (2) years. The purpose of these efforts were two-fold: To develop a low inductance CVR that could easily be integrated into fast pulsed thyatron circuits and develop a method of directly measuring current rate of change (di/dt) at the high bandwidth.

This report contains the results of these efforts and a simplified description of how the CVR and di/dt probes were designed and fabricated.

**SP628;** 1982 June. 233-243. Anderson, J. M. Wide-frequency-range current transformers and application to pulsed power systems.

**Key words:** current transformer; wide-band transformer.

Current transformers, constructed as a uniform toroid, can have excellent high frequency response into the microwave region. Their natural isolation against ground loops and ability to feed standard 50 ohm coaxial lines make them ideal for current sensing in high-power pulsed systems. Transformers having response from  $4 \times 10^{-2}$  Hz to  $\sim 300$  MHz, ixt product of 72 Amp-sec (250 kA for 290  $\mu$ s) and droop of 0.025%/ms have been constructed with all-ferrite cores.

These transformers have been applied to measurement of current near current-zero in the testing of high-power vacuum interrupters. Currents  $\sim 10$  kA were commutated to zero in 10  $\mu$ s and post arc currents lasting 2  $\mu$ s with 500 amperes peak were detected with current transformers. The ability to introduce opposing currents in the window of the transformer allows cancellation of capacitive current driven by the large recovery voltage.

**SP628;** 1982 June. 248-255. Kolibas, R. E.; Corbiere, P. A.; Moriarty, J. J. Data acquisition and processing techniques.

**Key words:** current measurements; pulse power system; signal transmission; system fault isolation; thyratrons.

Current measurements, signal transmission, and system fault isolation of a line type modulator have been accomplished in the presence of pulse power noise. This paper presents techniques successfully utilized to achieve valid results.

**SP628;** 1982 June. 256. Scarlett, W. R. A technique for measuring beam current density in the Antares Electron Gun.

**Key words:** Antares Electron Gun; beam current; electron flux.

The Antares Electron Gun produces a radial beam of high energy electrons for controlling the discharge in a large laser power amplifier. The gun delivers a 5  $\mu$ sec pulse of 450-550 kev

electrons with a current density of 50-100 mA/cm<sup>2</sup>. The 9.3 m<sup>2</sup> beam is delivered through 48 foil windows.

Because of the low electron flux, traditional means of making high resolution measurements of the time integrated beam uniformity have not proven very useful. We have developed a technique by which Cerenkov light produced in a plastic radiator placed above a foil window is recorded photographically and then measured with a densitometer. This data is then reduced to provide the integrated current density.

The design, calibration and performance of this technique will be presented. An extension of the technique to provide time resolved measurements will also be discussed.

**SP628;** 1982 June. 257-265. Rhee, M. J. Thomson spectrometer measurement of heavy ion beams produced by a pulse powered plasma focus device.

**Key words:** charge to mass ratio; energy resolved emittance; energy spectrum; Thomson spectrometer.

A compact Thomson spectrometer is constructed for the purpose of observing helium, nitrogen and argon ions accelerated in a pulse powered plasma focus. The spectrometer employs a single aperture system and CR-39 plastic as a detector. The energy, charge state and mass of the ions are determined by analyzing the Thomson parabolas. Also methods of obtaining the energy spectrum and the energy-resolved emittance from the same Thomson parabolas are discussed.

**SP628;** 1982 June. 266. McDaniel, D. H. Current measuring diagnostic techniques for high di/dt particle beam accelerator.

**Key words:** cavity current monitors; current measurements; current viewing resistors; high di/dt particle beam accelerator; Rogowski coils.

Sandia National Laboratories has developed the 10 TW Proto-II and 30 TW PBFA-I accelerator. The Proto-II accelerator has a di/dt of  $2.5 \times 10^{14}$  A/s and has delivered  $5 \times 10^6$  A to an imploding plasma load. PBFA-I has a di/dt of  $1.5 \times 10^{15}$  A/s and has delivered  $1.5 \times 10^6$  A to an electron beam diode load. At these values of di/dt and current we have surpassed the limits at which current viewing resistors (CVR's), Rogowski coils, cavity current monitors and B-dot probes are capable of giving accurate measurements when closer than 15 cm to the load.

**SP628;** 1982 June. 267-276. Leeper, R. J.; Burns, E. J. T.; Johnson, D. J.; McMurtry, W. M. Proton current measurements using the prompt gamma ray diagnostic technique.

**Key words:** current measurements; gamma ray diagnostic technique.

Prompt gamma ray signals from the nuclear reaction  ${}^7\text{Li}(p,\gamma){}^8\text{Be}$  have been used to make time resolved proton current measurements. In these measurements, the proton beam was allowed to strike cylindrical thick lithium metal targets. The time integrated proton current was measured using gamma activation of copper via the reaction  ${}^{63}\text{Cu}(\gamma,n){}^{62}\text{Cu}(\beta^+)$ . The positron activity of the copper sample was easily measured using coincidence counting techniques. The number of  ${}^{62}\text{Cu}$  atoms produced per proton incident on a thick Li metal target was determined with separate calibration runs performed on the Sandia 2.5 MeV Van de Graaff accelerator. The time history of the prompt gamma production was measured using six EGG NPM-54 scintillator photomultiplier combinations shielded by 96.5 cm of concrete and 5.1 cm of Pb. The use of six scintillator photomultiplier combinations was necessary to increase the statistical precision of the data. The normalization of the prompt gamma time history data with the total time integrated proton current measurement yielded the absolute time resolved proton current on target. Data from runs performed on the Sandia Proto I accelerator will be presented.

**SP628;** 1982 June 277-288. Katzenstein, J.; Caton, W.; Wilkinson, G. M. The measurements of pulsed electric currents by the Faraday effect.

**Key words:** Faraday effect; pulsed electric currents.



The Faraday effect has been known for over one hundred years and has been applied extensively to the measurement of magnetic fields. Its use for the measurements of electric current is, however, less common because the magnetic field arising from the current flow in an arbitrary circuit in general has a spatial variation. Hence, the calibration of a current probe employing the Faraday effect involves geometric factors such as the dimensions of the rotative medium and its position relative to the circuit. An obvious way out of this difficulty is to design the optical path in the rotative medium so that it encircles the current.

**SP628;** 1982 June. 289-299. Shannon, J.; Chu, E.; Richardson, R.; Wilkinson, M.; Trivelpiece, C. **Cavity current monitors.**

**Key words:** current monitors; current probe; current pulses; pulse generators; Rogowski coils.

In measuring short ( $\sim 10$  ns risetimes), high ( $\sim$  MA) current pulses, a single turn  $\vec{B}$  probe is useful only when the current path is precisely known. On the other hand, self-integrating resonance-free Rogowski coils are relatively difficult to build.

We present a new type of current monitor that is predictable, simple in construction and immune to capacitive pickups. These monitors are basically cavities machined in the current carrying conductors. We will discuss the design criteria and the high frequency response of these cavity current monitors along with the late time effects due to resistive losses in the wall of the cavity.

**SP628;** 1982 June. 310-315. Stewart, J. G., Jr.; Petty, W. A. **High-voltage monitoring and control through fiber optics.**

**Key words:** electromagnetic pulse; fiber optics; Marx generators; Remote Command Data Link.

Recent advances in the field of fiber optics have enhanced our ability to monitor and control high voltage in a hostile electromagnetic pulse (EMP) environment. Harry Diamond Laboratories has utilized these advances to pursue the development of a Remote Command Data Link (RCDL) for the Army's threat-level EMP simulator. This simulator utilizes twin Marx generators which can produce output voltages in excess of  $\pm 3$  MV. Through the use of the RCDL, this simulator can be remotely fired and real-time oscillograph records made that represent the  $\pm 3$  MV voltage waveforms that are impressed across the simulator peaking capacitors.

The RCDL was designed to allow normal pulser diagnostic maintenance, Marx output waveform monitoring, and adjustment of the Marx timing signals from a command and control center located approximately 30 m from the pulser. Specifically, the RCDL features synchronized command firing of the bilateral Marx generators, performance check of the pulser high-voltage trigger system, Marx generator erection waveform, advance or delay of a single Marx trigger for optimum simulator performance, and interlock with the simulator console for the arm and abort function.

The RCDL has recently been made an integral part of the Army's threat-level EMP Simulation Facility, located at Woodbridge, VA. This system is presently being evaluated for long-term performance. Preliminary data reveal that the RCDL provides the desired design features with reliable performance.

This paper presents an overview of the RCDL with emphasis placed on its usage in a particular EMP test facility. A follow-up paper by the Physics International Company presents a detailed circuit design of this system.

**SP628;** 1982 June. 316-319. Lyons, S. **Remote Command Data Link provides enhanced simulator performance in high EMP environment.**

**Key words:** EMP simulator; Marx erection time; Marx generators; Remote Command Data Link.

The Remote Command Data Link (RCDL) system was designed to provide an advanced method of determining EMP simulator performance on a shot-to-shot basis.

**SP628;** 1982 June. 320. Thuot, M. E.; Scarlett, W. R. **A fiber optic monitoring system for Antares Pulse Power System.**

**Key words:** Antares; calibration; inertial confinement fusion studies; pulse generators.

Antares is a 40 kJ  $\text{CO}_2$  laser system being built for inertial confinement fusion studies. The electron beam controlled discharge in the laser power amplifiers is driven by eight 1.2 MV, 300 kJ, 2 microsecond pulse generators. Each electron gun produces a 5 microsecond pulsed beam of 550 keV electrons with 50 ma/cm<sup>2</sup> current density and total beam area of 9.3 m<sup>2</sup>.

An electro-optic interface to a computer based control and data acquisition system has been developed to provide a capability for the measurement and operational monitoring of pulsed analog waveforms and high voltage system timing information.

Each interface channel consists of a signal powered transmitter, a fiber optic cable, and an optical receiver which interfaces through a CAMAC compatible module to the control system. The data channel is capable of rejecting 600 kV of common mode voltage, and operating in an electromagnetic interference environment of 500 kV/m and 50 kA/m at 140 kHz.

The analog transmitters send 10 MHz bandwidth amplitude modulated information to transient waveform digitizers in the data system. During operation about 100 data channels monitor voltage and current in each pulser and anode current density in the laser power amplifier. These devices have also been used to measure electron beam current density during electron gun testing.

Timing information of 2 ns resolution originates at each stage of trigger amplification and main pulse output in the ten power amplifier pulsers. The 120 channels of information are processed to provide a complete prefire diagnostic of each pulser.

The design, calibration, and performance of this system and its components will be presented.

**SP628;** 1982 June. 325-340. Boyer, W. B.; Neau, E. L. **Data recording techniques for the Sandia Particle Beam Fusion Accelerator.**

**Key words:** CAMAC pulse processing modules; inertial confinement fusion; Sandia Particle Beam Fusion Accelerator; SuperMite.

A data handling facility has been developed for the Sandia Particle Beam Fusion Accelerator (PBFA-I). The facility records and processes nanosecond diagnostic signals from both machine performance and experiment diagnostic monitors. The system consists of an EMP-shielded cable plant, two minicomputers, coax switches, transient waveform recorders, CAMAC pulse processing modules, and trigger/fiducial timing generators. All components are calibrated under either manual or computer control. Waveforms are recorded and calibrated by the system with an amplitude accuracy of  $\pm 1\%$ . Signals from different monitors can be aligned in time to within  $\pm 4$  ns. The facility is capable of supporting multiple simultaneous users. Applications software has been developed to support calibration, data acquisition, and data reduction. The facility is operational and is supporting two accelerators.

**SP628;** 1982 June. 341-354. Malewski, R.; McComb, T. R.; Collins, M. M. C. **An evaluation of digital recording equipment and numerical correction techniques in impulse measurement.**

**Key words:** analog-to-digital converters; error caused by response time; impulse measurements; numerical correction.

The application of analog-to-digital converters to the measurement of short-duration impulses is discussed. The desired accuracy of the measurement is used to derive the performance requirements of the analog-to-digital converter. The practical application of this analysis is illustrated by a brief summary of an inter-laboratory comparison of two recorders using both full and chopped lightning impulses with crest values approximately 100 kV. One recorder was a micro-processor controlled digital waveform recorder mounted in a special shielding enclosure developed at the Hydro Quebec Research Institute (IREQ); the other was a National Research Council of Canada (NRCC) oscilloscope whose performance had previously been



demonstrated in work at NRCC on high voltage impulse measuring standards. The relative accuracy of the two recorders was measured and their ability to resolve glitches on a smooth impulse was investigated. In order to investigate the ability of the IREQ digitizer to correct for errors caused by the response time, comparative measurements were made using two very different impulse voltage dividers connected in parallel. The faster divider was connected to the NRCC oscilloscope and the slower one to the IREQ digitizer. The digital processing capability of the IREQ system was used to calculate an approximation to the original impulse and this reconstructed impulse was compared with the measurement on the faster system. In addition Fourier Analysis was used to reconstruct the impulse and the two methods of reconstruction were compared.

**SP628;** 1982 June. 355-364. Poliner, R. E.; Reed, T. J. *Analysis of a power system transient recording laboratory.*

**Key words:** electrical transient phenomena; transient recording laboratory; transient surges.

Under a project sponsored by the Electric Power Research Institute, two automated Transient Recording Laboratories have been developed to measure and record naturally occurring electrical transient phenomena on transmission lines. The laboratories are now installed and fully operational on the Florida Power and Light transmission network at 500 kV and 138 kV substations. This paper describes noise suppression techniques and methods utilized to insure data integrity in a high voltage substation environment.

**SP628;** 1982 June. 365-377. Cunningham, E. E. *Application problems using instrumentation amplifiers in the pulse power environment.*

**Key words:** instrumentation amplifiers; pulse power environment.

Difficult and unusual problems arise when low level signals must be accurately measured in the pulse power environment. Usually involved with signals immediately following the pulse, this application demands unique capabilities of the signal processing instrumentation. This paper discusses necessary amplifier and signal conditioner characteristics in addition to shielding and cabling recommendations. Test results involving pulse common mode signals are presented to illustrate the effects of improper shielding and cabling.

**SP628;** 1982 June. 381-391. Trivelpiece, C.; Richardson, R.; Shannon, J.; Smith, J. B. *Digital correction of cable attenuation losses.*

**Key words:** cable attenuation; Fast Fourier Transforms; high speed transient digitizers; pulsed power generators.

The use of sensitive electronics on large pulsed power generators often necessitates long (> 50 ft) signal cables. Many of the signals measured have risetimes less than 10 ns. The long cables cause a significant degradation in the risetime and shape of these signals. Attenuating low frequencies using a passive compensation network is one solution to this cable loss problem. However, when data acquisition is accomplished by computers and high speed transient digitizers, it is possible to accurately correct for cable attenuation without the problems associated with passive compensators. We will discuss a technique for using Fast Fourier Transforms and waveform correction without introducing additional errors.

**SP628;** 1982 June. 392-407. Lawton, R. A. *Precision picosecond-microsecond electromagnetic waveform measurements at NBS.*

**Key words:** Automated Pulse Measurement System; electromagnetic waveform measurements.

Continuing research in the measurement science of electromagnetic waveforms has resulted in the development of an Automated Pulse Measurement System (APMS). This system consists of a sampling oscilloscope mated with a minicomputer to provide for automatic acquisition and processing of repetitive pulses with durations and transition times in the picosecond to microsecond time frame. In addition, work has been started to

add single transient capability to the APMS.

The development of this capability has required the careful development of the electronic circuit interfacing between the sampling oscilloscope and the minicomputer and the development of the appropriate software to allow the scope to be properly controlled by the computer.

Vertical and horizontal calibration techniques have been developed which provide an order of magnitude improvement in accuracy.

Reference waveform generators have been developed and new ones are contemplated to serve as a check on the complete measurement system.

Finally, a measurement system analysis has been performed which includes system modeling, signal parameter characterization and optimal data processing algorithm identification.

With the APMS we are now able to characterize noise free, repetitive time domain waveforms with an uncertainty of 1% of full scale in amplitude and 0.5% of full scale on the time axis.

In addition, with our best waveform generators, we can do characterization in the frequency domain over the frequency range 5 MHz to 10 GHz.

**SP629.** Wollin, H. F.; Barbrow, L. E.; Heffernan, A. P., eds. *Report of the 66th National Conference on Weights and Measures 1981. Natl. Bur. Stand. (U.S.) Spec. Publ. 629; 1982 January. 275 p. Available from: NTIS; PB 82-178997.*

**Key words:** education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures.

These are the proceedings of the 66th National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in St. Louis, Mo., July 13-17, 1981, and attended by State, county, and city weights and measures officials, and representatives of the Federal Government, business, industry, and consumer organizations. Reports by the several standing and annual committees of the Conference comprise the major portion of the publication. Included also are papers presented by Conference officials and other authorities from Government and industry.

Major issues discussed at the National Conference included measurement science education, enforcement uniformity, national type approval, inch-pound and metric labeling provisions, new design and performance requirements for weighing and measuring technology, metric conversion of retail gasoline dispensers, weights and measures program evaluation studies of model State laws and regulations and their adoption by citation or other means by State and local jurisdictions, and a report of States conducting grain moisture meter testing programs. *These proceedings include the following papers (indented):*

**SP629;** 1982 January. 1-3. Stadolnik, E. H. *Priorities for progress.*

**SP629;** 1982 January. 5-13. Tholen, A. D. *Gateway to a great day.*

**SP629;** 1982 January. 15-20. Collier, C. J. *The future of standards policy.*

**SP629;** 1982 January. 25-27. Hurley, R. *Services available to NCWM from the advertising council.*

**SP629;** 1982 January. 29. Phillips, L. J. *Developing a national training program for weights and measures officials.*

**SP629;** 1982 January. 31-33. Weaver, M. A. *An opportunity for professional training.*

**SP629;** 1982 January. 35-36. Valtri, S. F. *Northeastern weights and measures association.*

**SP629;** 1982 January. 37. Southers, R. *American petroleum institute.*

**SP629;** 1982 January. 39. Johanson, A. E. *Industry committee on packaging and labeling.*

**SP629;** 1982 January. 41-45. Delfino, E. *Task force on national*



type approval.

SP629; 1982 January. 47-48. Cockrell, D. J. National scale men's association.

SP629; 1982 January. 49-50. Lloyd, R. J. Scale manufacturers association.

SP630. Westley, F. Oxidation of sulfite ion by oxygen in aqueous solution—A bibliography. *Natl. Bur. Stand. (U.S.) Spec. Publ. 630*; 1982 March. 34 p. Available from: NTIS; PB 82-214438.

Key words: aqueous solution; bibliography; bisulfite ion; chemical kinetics; oxidation; oxygen; sulfite ion; sulfur dioxide.

A list of references is provided for published papers and reports containing rate constants or mechanisms for the oxidation of S(IV) by oxygen in aqueous solution, with or without catalysts. Three hundred and twenty papers are listed, the period covered extending from 1897 to 1981.

SP631. Gass, S. I. Oil and gas supply modeling. Proceedings of a Symposium held at the Department of Commerce; 1980 June 18-20; Washington, DC. *Natl. Bur. Stand. (U.S.) Spec. Publ. 631*; 1982 May. 778 p. Available from: NTIS; PB 82-234139.

Key words: cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis.

The symposium on Oil and Gas Supply Modeling, held at the Department of Commerce, Washington, DC (June 18-20, 1980), was funded by the Energy Information Administration of the Department of Energy and co-sponsored by the National Bureau of Standards' Operations Research Division. The symposium was organized to be a forum in which the theoretical and applied state-of-the-art of oil and gas supply models could be presented and discussed. Speakers addressed the following areas: the realities of oil and gas supply, prediction of oil and gas production, problems in oil and gas modeling, resource appraisal procedures, forecasting field size and production, investment and production strategies, estimating cost and production schedules for undiscovered fields, production regulations, resource data, sensitivity analysis of forecasts, econometric analysis of resource depletion, oil and gas finding rates, and various models of oil and gas supply. This volume documents the proceedings (papers and discussion) of the symposium. *These proceedings include the following papers (indented):*

SP631; 1982 May. 1-6. Murphy, F. H. Goals and purposes of the energy information administration/National Bureau of Standards symposium on oil and gas supply modeling.

SP631; 1982 May. 7-15. Schanz, J. J., Jr. Oil and gas supply: Public perception, modeler's abstraction, and geologic reality.

SP631; 1982 May. 16-141. Hubbert, M. K. Techniques of prediction as applied to the production of oil and gas.

SP631; 1982 May. 142-170. Stitt, W. C. Current problems in oil and gas modeling.

SP631; 1982 May. 171-199. Miller, B. M. The evolution in the development of petroleum resource appraisal procedures in the U.S. Geological Survey.

SP631; 1982 May. 200-256. Ducastaing, M.; Harbaugh, J. W. Forecasting future oil field sizes through statistical analysis of historical changes in oil field populations.

SP631; 1982 May. 257-271. Kaufman, G. M. Issues past and present in modeling oil and gas supply.

SP631; 1982 May. 272-294. McFarland, J. W.; Aggarwal, A.; Parks, M. S.; Lasdon, L. Analysis of investment and production strategies for a petroleum reservoir.

SP631; 1982 May. 295-309. Wood, J. H. A methodology for estimating oil and gas production schedules for undiscovered fields.

SP631; 1982 May. 310-349. Lohrenz, J.; Monash, E. A. Some modern notions on oil and gas reservoir production regulation.

SP631; 1982 May. 350-368. Root, D. H. Historical growth of estimates of oil- and gas-field sizes.

SP631; 1982 May. 369-410. Nissen, D. The economic accounts of the resource firm.

SP631; 1982 May. 411-419. Zaffarano, R. Gulf Coast undiscovered resource data collection system.

SP631; 1982 May. 420-431. Garland, T. M.; Wood, J. H. A methodology for estimating cost of finding, developing, and producing undiscovered resources.

SP631; 1982 May. 432-444. Eck, T. R. The outlook for oil exploration and development.

SP631; 1982 May. 445-455. Ramsey, J. B. Models, understanding and reliable forecasts.

SP631; 1982 May. 456-465. McDonald, S. L. The regulatory framework in oil and gas supply modeling.

SP631; 1982 May. 466-489. Drew, L. J.; Attanasi, E. D. Firm size and performance in the search for petroleum.

SP631; 1982 May. 490-534. Harris, C. M. Sensitivity analysis of forecasts for midterm domestic oil and gas supply.

SP631; 1982 May. 535-552. Deshmukh, S. D. Natural resource decisions involving uncertainty.

SP631; 1982 May. 553-563. Eppe, D.; Hansen, L. The depletion of U.S. petroleum resources: Econometric evidence.

SP631; 1982 May. 564-580. Fisher, W. L. Oil and gas finding rates in projection of future production.

SP631; 1982 May. 581-629. O'Neill, R. P. Issues in forecasting conventional oil and gas production.

SP631; 1982 May. 630-646. Cherniavsky, E. A. Oil/gas supply modeling considerations in long-range forecasting.

SP631; 1982 May. 647-660. Ciliano, R.; Hery, W. J. An integrated evaluation model of domestic crude oil and natural gas supply.

SP631; 1982 May. 661-687. Murphy, F.; Trapmann, W. An evaluation of the Alaskan hydrocarbon supply model.

SP631; 1982 May. 688-717. Brashear, J. P.; Morra, F.; Everett, C.; Murphy, F. H.; Hery, W.; Ciliano, R. A prospect specific simulation model of oil and gas exploration in the outer continental shelf: Methodology.

SP632. Locke, J. W., ed. Laboratory accreditation: Future directions in the United States. Proceedings of the NBS Workshop on Laboratory Accreditation held at the National Bureau of Standards; 1981 November 16-17; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 632*; 1982 March. 172 p. SN003-003-02392-2.

Key words: criteria; definitions; history; international trade; laboratory accreditation; need.

The purpose of the Workshop sponsored by the National Bureau of Standards was to provide a public forum for the expression of views upon which recommendations could be developed to bring about a desirable and effective distribution of responsibilities between government and private sectors in the area of laboratory accreditation. The Workshop was initiated in response to two related requests to change the Department of Commerce's (DoC) National Voluntary Laboratory Accreditation Program (NVLAP) in order that NVLAP's laboratory accreditation activities would be transferred to the private sector and DoC's role would be limited to that of an accreditor of accreditation systems.

As a basis for initiating public comment, 20 invited participants presented papers in five sessions: 1) background of U.S. laboratory accreditation; 2) international trade implications of laboratory accreditation; 3) need for laboratory accreditation; 4) criteria for recognizing laboratory accreditation systems; and, 5) a mechanism to accredit organizations which accredit testing laboratories. Approximately 200 people attended the Workshop and the written and oral reviews of all who participated are summarized in these



Proceedings. Also included are written comments (letters) which were sent in by participants and other interested persons after the Workshop was concluded. *These proceedings include the following papers (indented):*

**SP632; 1982 March. 24-27. Whitaker, B. Meaning of accreditation and certification.**

**Key words:** accreditation; certification; functions; laboratory accreditation; product certification; system operation.

The common aspects of laboratory accreditation and product certification as these two terms are commonly used, as well as characteristics of each which delineate their distinctively different functions, are described. An understanding of the differences in the functions of each when applied to a system operation is essential if users of such systems are to appraise properly their significance.

**SP632; 1982 March. 28-35. Young, T. R. History of laboratory accreditation in the U.S.**

**Key words:** accreditation; general needs; historical; laboratory evaluation.

The chronological order of establishment of seventy laboratory accreditation programs is presented, including their motivation and scope of testing interest. Characteristics and historical trends of these accreditation programs are discussed with particular attention given to programs designed to serve large and/or general needs for laboratory evaluation and accreditation.

**SP632; 1982 March. 36-39. Hyer, C. W. Status of laboratory accreditation in the United States.**

**Key words:** environment; laboratory accreditation; updated information.

This presentation briefly describes the status of laboratory accreditation at the time of the publishing of the work "Principal Aspects of Laboratory Accreditation Systems," in July 1980. NVLAP, AALA, IEEE and IECQ systems are described to present updated information. The current and near future environment that does and will affect laboratory accreditation is discussed. The size of the problems to be addressed and a prediction of the possible outcomes and reasoning is offered.

**SP632; 1982 March. 40-42. Abelson, D. S. International trade implications of laboratory accreditation.**

**Key words:** accreditation; laboratory; legal system; standards code; testing laboratories.

The reciprocal acceptance of tests and test data is likely to be the most significant technical issue in future standards-related discussions on trade. The mechanism for dealing with these trade issues is the General Agreement on Tariffs and Trade (GATT)—Agreement on Technical Barriers to Trade, popularly known as the "Standards Code." In bilateral discussions with government officials of other countries which have signed the code, the Office of the Special Trade Representative encourages foreign governments to recognize the American system of private testing laboratories with our legal system and product liability laws, are far better guarantors of reliability than government agencies. There is a problem however, responding to foreign requests for "official" approval, and there is much interest in the evolving Good Laboratory Practices Program in the OECD and the International laboratory accreditation conferences.

**SP632; 1982 March. 43-45. Locke, J. W. Purpose of laboratory accreditation.**

**Key words:** international; international trade; laboratory accreditation; task force.

Task Force C of the International Laboratory Accreditation Conference (ILAC) has prepared a report which describes a number of needs for laboratory accreditation. Detailed examples illustrating each need are presented. Objectives of laboratory accreditation systems are described. Effects on all segments of the laboratory accreditation community are summarized, as well

as effects on international trade.

**SP632; 1982 March. 46-51. Hess, E. H. The need for a practical laboratory accreditation program from the perspective of a small multi-discipline independent laboratory.**

**Key words:** analytical laboratories; clients; international trading; laboratory accreditation; public.

Most independent analytical laboratories set high professional standards for themselves, not only because of personal integrity, but because such standards are prerequisites to lasting acceptance of our services in the marketplace. Quality assurance systems have been put in place at many laboratories, but these are incomplete until they stand the scrutiny of a qualified outside source. Laboratory accreditation must provide objective and comprehensive evidence of a laboratory's qualifications and capabilities documented by a third party. Lancaster Laboratories supported the original Department of Commerce proposal for a National Voluntary Laboratory Accreditation Program (NVLAP) but that support diminished substantially with publication of the final rule because the program is structured on a product-by-product basis rather than on a class of technology basis. A private sector program, the American Association for Laboratory Accreditation, now exists which can meet our needs, and the NVLAP should be adjusted to one of monitoring and accrediting private sector agencies so as to support our international trading interests. Advantages of accreditation to the laboratories, clients and the public are fully explored.

**SP632; 1982 March. 52-53. Levelius, W. H. Independent laboratory with many separate laboratory locations.**

**Key words:** accreditation procedures; corporate; Corporate Standard Quality System; individual; laboratory.

Several hundred corporations exist which operate from executive office/laboratory facilities with branch laboratories at other locations. Approval of the Corporate Standard Quality System implemented at all facilities would save paperwork, time and cost to both the laboratory and accreditors. Systems to be addressed in the Master Quality Program are listed. Management procedures for control of the system throughout the corporation are described. Similarities, differences, advantages and disadvantages between corporate control and individual site accreditation are discussed. Several concerns are expressed about present and proposed accreditation procedures.

**SP632; 1982 March. 54-56. Gaynor, R. D. Why concrete laboratory accreditation—Why NVLAP.**

**Key words:** commercial laboratories; concrete; laboratory accreditation; NVLAP; testing.

Ready mixed concrete producers (manufacturers) support the need for laboratory accreditation. In commercial concrete construction acceptance testing is performed by commercial laboratories, but there are no objective standards for the quality assurance and quality control of these laboratories. The operations are small and highly competitive. Too often improper testing procedures and errors result in low strength test results which must be investigated to determine if remedial action is needed in the structure. These delays disrupt the construction process. Accreditation also provides a standard by which the concrete producers own laboratory staff can be measured and thereby gain recognition that is denied them in the absence of an objective detailed standard for performance.

**SP632; 1982 March. 57-58. Grant, J. A. Laboratory accreditation as viewed by a manufacturing concern.**

**Key words:** commercial; independent; laboratory accreditation; manufacturing concerns.

Laboratory accreditation is judged to be both necessary and desirable. Accreditation provides an excellent means to assist in the selection of a commercial or independent laboratory. However, it should not be necessary for manufacturing concerns operating in-house laboratories to have their facilities accredited in order to test and certify their own products. The technical competency of most of these laboratories is already well



recognized and needs no further verification.

Accreditation must be based on laboratory performance; staff qualifications and organization are secondary. Competent and knowledgeable assessors are the key to a good laboratory accreditation system.

**SP632; 1982 March. 59-60. Waters, F. Problems confronting a U.S. firm exporting a complex product.**

**Key words:** exporting; governmental regulations; manufacturer; tractor model.

In exporting farm tractors, a U.S. manufacturer must meet specific governmental regulations which vary from country to country. Regulations covering some 52 components have been identified. A review of the requirements in 30 countries indicates that some regulate most of these components while others regulate only a few. Government and industry need to work together so that test performed in the United States showing compliance to foreign regulations will be accepted by foreign government authorities.

**SP632; 1982 March. 61-62. Pinkerton, D. F. Laboratory accreditation of interest to the National Conference of States on Building Codes and Standards.**

**Key words:** laboratory accreditation; local; NCSBCS; state.

The National Conference of States on Building Codes and Standards (NCSBCS) has supported laboratory accreditation since the early 1970's. Such systems should be voluntary, should encompass a peer group evaluation process, and should be acceptable throughout the United States. The voluntary laboratory accreditation systems must be monitored by a disinterested third party. NCSBCS wishes to become an equal partner in a voluntary laboratory accreditation system that continues to ensure the health and life safety of the residents of our states and for this purpose it is considering establishing an advisory group of state and local officials to keep everyone apprised of its interests.

**SP632; 1982 March. 63-64. Alexander, R. E. Advantages to the Nuclear Regulatory Commission of third-party laboratory accreditation programs.**

**Key words:** government operated; laboratory accreditation; Nuclear Regulatory Commission.

The Nuclear Regulatory Commission (NRC) has expressed a strong interest in third-party laboratory accreditation. The advantages and disadvantages of a government operated (but not NRC operated) system such as the National Voluntary Laboratory Accreditation Program are described as relevant to NRC, the nuclear power industry and the affected workers.

**SP632; 1982 March. 65-67. Swankin, D. A. The consumer interest in laboratory accreditation.**

**Key words:** consumer interest; consumer rights; laboratory accreditation.

The consumer interest in laboratory accreditation is by no means an easy and obvious interest to describe. It is based upon four fundamental consumer rights: the right to be informed, the right to choose, the right to safety, and the right to be heard. The characteristics which effective laboratory accreditation systems must have, based upon these four rights are described. The end use consumer is best served by systems which have the most integrity, have the most quality, are the most efficient and cost effective, display the greatest sense of public responsibility, and have the best accountability. The concept of NVLAP being an "accreditor of accreditors" might make a lot of sense but it would need to develop over a period of years in stages.

**SP632; 1982 March. 68-69. Berman, G. A. Work of ASTM committee E-36 on criteria for testing laboratory evaluation and accreditation.**

**Key words:** ASTM committee E-36; inspection agencies; laboratories; testing.

Since its formation in 1973, ASTM Committee E-36 on Criteria for the Evaluation of Testing and Inspection Agencies has been actively working to develop consensus criteria that could be used by others to evaluate and accredit laboratories. This paper highlights the activities of the Committee.

**SP632; 1982 March. 70-72. Pritsker, T. P. Characteristics of laboratory accreditation systems—The product certification program point of view.**

**Key words:** laboratory accreditation; product certification program; testing laboratory.

A product certification program depends on the accuracy and reliability of the testing laboratory as a basis for certification. The certifier needs accurate testing, within statistical limits, among the laboratories being used. The certifier should be able to accept test reports from accredited laboratories without hesitation. Accreditation will probably not play a substantial role in product liability actions. A viable acceptable accreditor must have technical expertise; competent personnel; ability to present or to transmit the latest methodology; organizational and administrative ability; and an assailable, unquestionable integrity beyond any reproach. The last requirement is the most difficult to provide, and when provided, leaves no need for being accredited by someone else.

**SP632; 1982 March. 73. Magnotti, J. F., Jr. General guidelines for a laboratory accreditation system.**

**Key words:** American Association for Laboratory Accreditation; International Laboratory Accreditation Conference; laboratory accreditation system; task force C.

This paper outlines the general criteria for establishing a laboratory accreditation system. It is consistent with the work done by Task Force C of the International Laboratory Accreditation Conference (ILAC). The guidelines, as contained in this paper, have been endorsed by the Board of Directors of the American Association for Laboratory Accreditation (AALA).

**SP632; 1982 March. 74-75. Kontje, H. C. The IEC's way of evaluating certifiers in participating countries.**

**Key words:** certifiers; evaluation; International Electrotechnical Commission; laboratory; test facilities.

The International Electrotechnical Commission (IEC) has developed the IECQ certification system on electronic components, including products such as resistors, capacitors, printed circuit boards, integrated circuits and connectors. A National Supervisory Inspectorate (NSI) in each country was examined by the National Supervisory Inspectorates of three other countries. In the United States, the NSI will evaluate laboratory and test facilities, in conjunction with an evaluation of the entire quality assurance system used by the manufacturer. Procedures used to evaluate the testing laboratories are described.

**SP632; 1982 March. 76-78. Forman, H. I. ILAC: A means for removing technical barriers to trade by recognizing laboratory accreditation systems in different countries.**

**Key words:** accreditation; ILAC; laboratories; national programs.

ILAC seeks first to promote the development of national programs for accrediting test laboratories, employing harmonized accreditation criteria, and then to promote the development of agreements by which importers will accept the results of tests made by accredited laboratories in exporting nations. An ultimate objective for ILAC may be to promote development of a treaty or worldwide agreement, possibly along the lines of the GATT code, by which signatory nations will agree to (a) operate national programs for accreditation of their test laboratories, (b) perform tests in accordance with mutually agreed upon standards, and (c) evaluate laboratories in accordance with mutually agreed upon criteria. Achievement of the foregoing objectives will serve to reduce or remove technical barriers to trade in the form of tests made by importers which are



unnecessarily duplicative of tests made by exporters.

**SP632; 1982 March. 79-80. Morris, C. R. Implementation of good laboratory practice: International considerations.**

**Key words:** laboratory; test data; toxic substances.

One of the first actions taken by the Organization for Economic Cooperation and Development (OECD) in the area of toxic substances was to develop an agreement on good laboratory practices (GLP). A group of experts met and agreed that in order to enhance the mutual acceptance of test data among countries and avoid non-tariff barriers to trade, the countries must harmonize and implement the utilization of test guidelines, OECD Principles of GLP, and have in place an internationally harmonized, national GLP compliance program. The group of experts has met for 3 years and will present their final recommendations to the OECD Management Committee in December 1981.

**SP632; 1982 March. 81-91. Young, T. R. Recognition of accrediting agencies—State of the art.**

**Key words:** accrediting agencies; laboratory; recognition.

A U.S. Department of Education Program is presented as representing the state of the art for recognition of accrediting agencies. The program's history, scope, administrative structure and procedures are discussed with special attention given to questions and issues that may bear upon considerations for establishing a similar program for recognition of laboratory accrediting agencies.

**SP632; 1982 March. 92-98. Rossi, L. R. Proposal to transfer the current NVLAP system into a system for accrediting private accreditation systems.**

**Key words:** accrediting laboratories; international; NVLAP system; United States.

The presentation centers around the American Association for Laboratory Accreditation (AALA) proposal that the role of the National Voluntary Laboratory Accreditation Program (NVLAP) be changed from that of accrediting laboratories to one of being an accreditor of accreditation systems and the primary link between the laboratory accreditation community in the United States and the international laboratory accreditation community.

**SP633. Schwartz, R. B.; Eisenhauer, C. M. Procedures for calibrating neutron personnel dosimeters. Natl. Bur. Stand. (U.S.) Spec. Publ. 633; 1982 May. 35 p. Available from: NTIS; PB 82-235961.**

**Key words:** air scatter; calibration; californium; dose equivalent; dosimeter; neutron; remmeter; room return.

Procedures are given for routine testing and calibration of neutron dosimeters and remmeters with radioactive neutron sources. The issues addressed include: the choice of neutron source; phantom construction; fluence to dose equivalent conversion; and the corrections for air scatter, room return, and anisotropic-neutron emission. Explicit, semi-empirical, analytic expressions are given for the room return correction, and calculated numerical values are given for air scatter.

**SP634. Lawton, R. A., ed. Proceedings of the waveform recorder seminar. Proceedings of the Seminar on Waveform Recorder Measurement Needs and Techniques for Evaluation/Calibration; 1981 October 15; Boulder, CO. Natl. Bur. Stand. (U.S.) Spec. Publ. 634; 1982 June. 97 p. Available from: NTIS; PB 82-242215.**

**Key words:** converters; electromagnetics; encoders; pulse; standards; waveform generation; waveform measurements; waveform recorder.

In the past, for the most part, precision electromagnetic measurements were concerned with the measurement of parameters for sinusoidal (or steady state) excitation and response, e.g., magnitude, phase, and power. One reason for the popularity of frequency domain measurement was that in this domain only one complete data point need be recorded to constitute a useful measurement. Recording a thousand data points as required for

precision time domain waveform measurements simply was not feasible. Today such frequency domain measurements are still important but now share their importance with transient pulse time domain measurements. With the emergence of integrated circuit components for (1) sampling or analog to digital conversion, (2) storage, and (3) control, real time digital waveform recording is now practical and widespread in usage. Furthermore, by coupling waveform recording components to minicomputers and microprocessors integrated circuitry it is now possible to record single events using compact systems (instruments) which acquire, record, process, and analyze transient signals. In fact, the incorporation of digital computation integrated circuitry appears to be a major driving force in expanding the role of waveform measurements in the academic, industrial and scientific communities.

We at the National Bureau of Standards are charged with the responsibility of encouraging the orderly development of consistent standards and measurement techniques. We have been actively engaged in waveform standards development for some time now and the papers in these proceedings will give a sample of what NBS and others in the waveform community have done already. The afternoon session consisted of a workshop which addressed the questions: Where do we go from here? and Why?, culminating in the selection of a steering committee for the development of standards for waveform recorders. *These proceedings include the following papers (indented):*

**SP634; 1982 June. 1-5. Nahman, N. S. Some generic waveform recorder problems.**

**Key words:** errors; pulse measurements; time domain measurements; waveform measurements; waveform recorders.

Because of physical limitations the waveform displayed by a waveform recorder is not an exact replica of the signal or pulse applied to its input. The term physical limitations pertains to the network and electronic-device effects which can slow down and/or otherwise distort the shape of an applied pulse or transient signal. The limiting factors can be roughly grouped into two categories (1) bandwidth or signal distortion limitation and (2) analog to digital conversion limitations. A brief discussion of these limitations is given to provide some insight into the technical topics to be discussed by the remaining seminar speakers.

**SP634; 1982 June. 7-21. Flach, D. R. Steady state tests of waveform recorders.**

**Key words:** analog-to-digital converter; digitizer; dynamic testing; effective number of bits; frequency domain; quantizing error; signal-to-noise ratio; time domain; transient recorder.

Sinusoidal stimuli are often used for the dynamic testing of waveform recorders and fast analog-to-digital converters. This approach has the advantages that sinewaves are well-defined signals, and are easily generated over a wide frequency range with parameters that are readily measurable. Two methods are presented for analyzing the data from such tests, and two resulting figures of merit, the rms signal-to-noise ratio (S/N ratio) and the effective number of bits, are discussed. In the frequency domain, the S/N ratio is obtained from the magnitude spectrum, which is calculated by performing a Fast Fourier Transform on a set of  $m$  code words weighted with a Hanning window. In the time domain, a sinewave is fitted to the set of data words, using a nonlinear least squares computation. The fitted curve is then compared with the original digitized data to calculate the S/N ratio. The results of sinewave tests on different types of waveform recorders are presented, along with a comparison of time domain and frequency domain analysis of the data. The influence of two specific types of analog-to-digital errors on the resulting S/N ratio are computed and presented as examples.

**SP634; 1982 June. 23-25. Crosby, P. S. Characterizing the dynamic performance of waveform digitizers.**

**Key words:** data reduction; sinewave; waveform digitizers.

The obvious question that comes to mind when one considers using a waveform digitizer for a specific application is: "Is it good enough?" The answer to that question has two states; yes or no. However, the number of states that the code sequence of a



digitizer can occupy can become astronomical in a pretty short time. Thus, the characterization of a digitizer must become an exercise in data reduction, coupled with careful consideration and selection of allowable test stimuli. The test stimulus should have low entropy, that is, the number of coefficients needed to describe it fully should be small in number.

**SP634;** 1982 June. 27-34. Souders, T. M.; Flach, D. R. **Measurement of the transient versus steady-state response of waveform recorders.**

**Key words:** analog-to-digital converter; digital processing; dynamic testing; sine-wave testing; transient digitizer; transient response; waveform recorder.

A simple test method is proposed in which the transient and steady-state responses of waveform recorders are compared. The transient signals employed in this method are single period sinusoids accurately characterized in terms of a steady-state sine wave from which they are derived. Digital recordings of the transient and steady-state waveforms are made with the test instrument and are subsequently compared. Differences are analyzed using time-domain digital processing. A gated S/H amplifier is used to produce the single period transients from a sine-wave input. Techniques are presented for generating the appropriate gating pulses, and for accurately comparing the transient and steady-state waveforms. Test results are included for three different instruments, having up to 10 bits of resolution and conversion rates to 100 MHz.

**SP634;** 1982 June. 35-46. Boyer, W. B. **Calibration techniques for a large computerized waveform recording system.**

**Key words:** calibration; digitizers; waveform calibration; waveform recording system; waveforms.

A transient waveform recording and processing facility has been developed for the Sandia Particle Beam Fusion Accelerator, PBFA 1. Signals from diagnostic monitors on the accelerator and associated experiments consist of transient pulses of 10-1000 ns duration and 1 to 5000 volts peak amplitude. The waveform recording system consists of 44 Tektronix 7912AD Transient Digitizers interfaced to a HP-1000/45 minicomputer. The facility also contains computer-controlled calibration, switching, and attenuation devices. The calibration and switching hardware can route either precision dc voltages or precision frequency frequency periodic signals to the attenuators and digitizers. Software has been developed to automatically calibrate the attenuators and digitizers and store the curves in disc files. These data are used to calibrate waveforms recorded from accelerator experiments. The facility cable system is also calibrated for frequency response using the 7912AD's in a semiautomatic mode. Waveform calibration consists of averaging to center of trace, linear amplitude adjustment, nonlinear sweep speed processing, and cable frequency response compensation. System tests indicate that waveforms can be calibrated to an amplitude accuracy of  $\pm 3$  percent. Signals recorded from different monitors can be aligned in time to within  $\pm 4$  ns.

**SP634;** 1982 June. 47-53. Ramboz, J. D.; Ondrejka, A. R.; Anderson, W. E. **Sampling-rate drift problems in transfer function analysis of electrical power cables.**

**Key words:** deconvolution; digital sampling; fast Fourier transforms; sampling-rate drift.

An examination of measurement problems caused by sampling-rate drift has been initiated at the National Bureau of Standards. This work arose from the study of degradation in underground power distribution and transmission cables, where precise measurements of radio-frequency dispersion characteristics (i.e., attenuation and phase delay as a function of frequency) are necessary. Cable dispersion results are obtained using time-domain-reflectometry and fast Fourier transform methods and spectra obtained from different data sets are compared. But because the data are necessarily taken at different times, drifts in sampling rate can occur and cause erroneous results in the frequency domain. Measurement methods for the detection of sampling rate drifts and computation methods for correcting the data are discussed and illustrated.

**SP634;** 1982 June. 55-67. Guido, A. A.; Fulkerson, L.; Stuckert, P. E. **Automatic pulse parameter determination with the computer augmented oscilloscope system.**

**Key words:** automated oscilloscope; computer aided measurement; laboratory automation; pulse analysis; pulse waveform analysis; waveform analysis; waveform recording.

The Computer Augmented Oscilloscope System (CAOS) is a special computer terminal facility intended for laboratory experiments involving waveforms and their interpretation. The system provides digital acquisition of waveform data, system control and calibration, data analysis, and graphic and alphanumeric display.

Pulse parameter determination requires the use of all system capabilities since a) hardware and software options must be chosen or controlled, b) the pulse waveform must be digitized, c) the appropriate analytical algorithms must be applied to the data and d) the results of analysis must be displayed. Specific attention is given to the algorithms required for pulse parameter determination and a new procedure for determining base and top magnitude of a pulse waveform is presented.

**SP634;** 1982 June. 69-88. Andrews, J. R.; Nahman, N. S.; Bell, B. A. **Status of reference waveform standards development at NBS.**

**Key words:** calibration; reference waveform generators; rise time; time domain measurements; transfer standards; transition duration; waveform generation; waveform measurements.

NBS has developed a (step-like) pulse generator for use as a transfer standard for transition duration (10%-90%),  $t_d$ . The generator consists of a tunnel diode step-like generator ( $t_d = 20$  ps) driving a low pass filter. Three filters are available for  $t_d = 50$ , 100, and 200 ps. The low-pass filters, of NBS design, are 30 cm long, 7 mm diameter, coaxial lines filled with a lossy Debye-type liquid dielectric. The mathematical model describing these low pass filters is quite accurate. The necessary parameters for the model can be obtained from independent measurements. The complete available output waveform into a matched load (50 ohms) can be predicted to within less than 1.5%. A companion step-like generator is presently under development to provide well-known top and baselines with a transition duration of less than one nanosecond.

**SP635.** Margolis, S. A., ed. **Reference materials for organic nutrient measurement.** Proceedings of a Workshop held at the National Bureau of Standards; 1980 October 23; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 635*; 1982 August. 51 p. SN003-003-02410-4.

**Key words:** food matrices; methods of measurement; nutrients; SRM's; stability; vitamins.

This publication is the formal report of the Workshop on Reference Materials for Organic Nutrient Measurement held at the National Bureau of Standards on October 23, 1980. There were seven formal presentations which provided the framework for three workshop sessions. Each workshop session focused on one of three groups of nutrients: (1) cholesterol, fat, and fat-soluble vitamins; (2) water-soluble vitamins; or (3) sugars. Each workshop session reported on the state-of-the-art in measurement techniques, suggested matrices which were appropriate for Standard Reference Materials (SRM's), and indicated areas where there were problems in measurement methodology. These recommendations are included in this publication. *These proceedings include the following papers (indented):*

**SP635;** 1982 August. 1-4. Tanner, J. T.; Pennington, J. A. T. **The role of Standard Reference Materials in the development of a sound data base for the assessment of human nutrition.**

**SP635;** 1982 August. 5-7. Uriano, G. A. **The process and requirements for the development of a Standard Reference Material.**

**SP635;** 1982 August. 8-12. Egberg, D. C. **An assessment of the accuracy and precision of the methods used for the measurement of organic nutrients in cereal and grain products.**



SP635; 1982 August. 13-17. Elkins, E. R. Accuracy and precision of nutrient methodology.

SP635; 1982 August. 18-24. Stewart, K. K. Problems in the measurement of organic nutrients in food products: An overview.

SP635; 1982 August. 25-29. Thornburg, W. Long term stability of organic nutrients in foods.

SP635; 1982 August. 30. Barnett, S. The long-term stability of organic nutrients in infant and adult dietary supplements.

SP635; 1982 August. 32-35. Margolis, S. A. Executive summary of workshop sessions.

SP636. Unger, P. S. NVLAP fifth annual report and directory of accredited laboratories. *Natl. Bur. Stand. (U.S.) Spec. Publ. 636*; 1982 September. 57 p. SN003-003-02421-0.

Key words: accredited laboratories; laboratory accreditation process; laboratory accreditation programs.

This annual report of the National Voluntary Laboratory Accreditation Program (NVLAP) is prepared in accordance with NVLAP Procedures (Title 15 CFR Parts 7a, 7b, and 7c). Part I summarizes significant activities, including program changes, accreditation actions, and ongoing discussions concerning laboratory accreditation on the national and international levels. Part II is a directory of laboratories currently accredited on behalf of the Secretary of Commerce.

SP637, Volume 1. Danielson, B. L.; Day, G. W.; Franzen, D. L.; Kim, E. M.; Young, M. Optical fiber characterization backscatter, time domain bandwidth, refracted near field, and interlaboratory comparisons. *Natl. Bur. Stand. (U.S.) Spec. Publ. 637, Vol. 1*; 1982 July. 205 p. Available from: NTIS; PB 83-111609.

Key words: attenuation; backscatter; bandwidth; index profile; measurements; optical fiber.

Optical fiber waveguide measurements are described. Systems to determine the backscatter, bandwidth, and index profile are covered in detail. Measurement comparisons between laboratories are given for fiber attenuation, bandwidth, numerical aperture, and core diameter.

SP639. Chidester, J. E., ed. Fire research and safety. Proceedings of the Fifth Joint Panel Meeting of the U.S.-Japan Cooperative Program in Natural Resources held at the National Bureau of Standards; 1980 October 15-24; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 639*; 1982 September. 394 p. SN003-003-02413-9.

Key words: arson; building design; combustion products; fire investigation; fire modeling; fire protection; human behavior; smoke control; smoldering; sprinkler systems; toxicity.

The Fifth Joint Panel Meeting of the United States-Japan Panel on Natural Resources (UJNR), Fire Research and Safety, was held at the National Bureau of Standards in Gaithersburg, MD, from October 15 through 24, 1980. The meeting consisted of in-depth technical sessions on arson and fire investigation, toxicity of combustion products, advances in sprinkler technology, and fire modeling. Progress reports briefly covered fire retardance, building design, smoke control, human behaviors in fires, and fire protection. Two days of informal sessions were held on toxicity, human behavior, detection and smoke properties, sprinklers, smoldering, and fire modeling. This meeting was held in conjunction with the Center for Fire Research's Annual Conference which included United States presentations of related technical subjects. The proceedings include the technical papers presented at the UJNR meeting along with the ensuing discussion and the summary reports prepared by each session chairperson.

The first meeting of the UJNR Panel on Fire Research and Safety was held in Washington, DC, from April 7-8, 1976, where the current activities in the United States and Japan on fire research and safety were introduced. After this exchange, the following six topics were selected for initial cooperation: toxicity, building systems, human behavior, smoke control, detection and smoke properties, and modeling of fire.

The participants resolved that the sixth meeting, to be held in Tokyo, would cover the following topics in-depth: (1) building systems and smoke control, (2) human behavior, (3) fire modeling, and (4) toxicity. Progress reports will be submitted in the areas of human behavior, fire modeling, toxicity, sprinklers, detectors, fire and smoke retardants, fire investigation techniques, and building systems and smoke control. *These proceedings include the following papers (indented):*

SP639; 1982 September. 2-10. Saito, F. Recent development of fire retardance.

SP639; 1982 September. 11-16. Clarke, F. Recent advances in flame retardance research.

SP639; 1982 September. 17-21. Wakamatsu, T.; Morishita, Y. Building systems and smoke control.

SP639; 1982 September. 22-25. Benjamin, I. Detection in U.S.A. 1979-1980.

SP639; 1982 September. 26-30. Horiuchi, S.; Jin, T. Human behavior.

SP639; 1982 September. 31-36. Miyama, J. Fire detection and smoke property.

SP639; 1982 September. 44-63. Karchmer, C. Early intervention in arson epidemics: Developing a motive-based intervention strategy.

SP639; 1982 September. 64-66. Kawamura, T. Incendiary fires in Japan.

SP639; 1982 September. 72-87. Kishitani, K.; Saito, F.; Yusa, S. Basic concept of toxic hazards in building fires.

SP639; 1982 September. 88-103. Birky, M. Preliminary comparison of combustion model in toxicity test method with a large scale fire scenario.

SP639; 1982 September. 104-115. Nishimaru, Y.; Tsuda, Y. Study of toxic gas generated during combustion—In case of natural and artificial lawn.

SP639; 1982 September. 122-154. O'Neill, J. Life safety factors involved in the use of sprinklers.

SP639; 1982 September. 155-175. Unoki, J. Sprinkler technology and design in Japan.

SP639; 1982 September. 176-224. Kung, H. Advances in residential sprinklers.

SP639; 1982 September. 231-235. Kinoshita, C.; Pagni, P. Laminar wake flame heights.

SP639; 1982 September. 236-247. Emmons, H. The computer fire code.

SP639; 1982 September. 248-259. Friedman, R. Recent U.S. progress in mathematical modeling of fire.

SP639; 1982 September. 266-307. Ohlemiller, T. Modeling of smoldering combustion propagation.

SP639; 1982 September. 308-364. Handa, T.; Yoshizawa, S.; Morita, M.; Fukuoka, M.; Tsushima, H.; Hashizume, Y.; Nakamura, T. Thermal processes in the smoldering of wood.

SP640. Shives, T. R.; Willard, W. A., eds. Innovation for maintenance technology improvement. Proceedings of the 33d Meeting of the Mechanical Failures Prevention Group held at the National Bureau of Standards; 1982 April 21-23; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 640*; 1982 October. 518 p. SN003-003-02425-2.

Key words: fault detection/location system; lubrication; maintenance; maintenance management; maintenance technology; manpower utilization; reliability assessment.

These proceedings consist of a group of 34 submitted entries (32



papers and 2 abstracts) from the 33d meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards, Gaithersburg, Maryland, April 21-23, 1981. The subject of the symposium was maintenance technology improvement through innovation. Areas of special emphasis included maintenance concepts, maintenance analysis systems, improved maintenance processes, innovative maintenance diagnostics and maintenance indicators, and technology improvements for power plant applications. *These proceedings include the following papers (indented):*

**SP640;** 1982 October. 2-16. Koury, A. J. **Maintenance technology concept.**

**Key words:** corrosion; failure prevention; human performance; material and material processing; mechanical and structural failure; operational environment; preventive maintenance; wear.

**SP640;** 1982 October. 17-26. Rolka, H. **Innovation for maintenance technology improvements.**

**Key words:** maintenance; maintenance costs; maintenance technology; technology centers; technology innovation.

The high cost and complexity of today's industrial operation makes it imperative that maintenance technology be put to work. In 1980 American industry spent in the range of 246 billion dollars in maintenance costs for plant facilities and equipment. These estimates do not take into consideration the cost of lost sales caused by production downtime and poor product quality. The need and opportunity for skilled, results oriented maintenance administrators has never been better nor more important. The address will focus on the more critical maintenance problems facing industry; their impact and some innovative productivity practices and concepts that hold great promise for the future.

**SP640;** 1982 October. 27-44. Middlebrook, V. S.; Andrews, G. D. **S. An overview of maintenance information systems functions.**

**Key words:** aircraft maintenance functions; maintenance information systems functions; management and financial functions; master planning; material and logistics functions; personnel/component/support shop functions; powerplant/component/support shop functions.

Aircraft Maintenance costs are escalating rapidly on practically every front. Maintenance information systems are one of the few areas where costs have remained relatively stable in recent years because computer hardware costs have continued to decrease. This has enabled the development of more cost-effective applications to control costs and manage aircraft maintenance. In this paper a framework of primary maintenance information systems functions is outlined. The list is all-inclusive and covers those functions which interface directly with the aircraft, the powerplant/component/support shops and the management and financial areas. Over fifty different functions are reviewed in some detail to present each potential user with a list he should consider in developing comprehensive maintenance systems. Implementation steps are also discussed and conclusions drawn.

**SP640;** 1982 October. 45-60. Slotter, L. E.; Shawver, W. R.; White, D. J. **Failure mechanism and cause analysis of structures: A paradigm for the analysis of failures or potential failures.**

**Key words:** engineering failure mode; failure; failure analysis; failure modes and effects analysis; maintenance (inspection) interval.

A novel heuristic failure analysis procedure that incorporates multidisciplinary considerations within a constructive framework to aid in the analysis of actual engineering failures or the failure potential of structures is described and discussed. The Failure Mechanism and Cause Analysis (FMCA) procedure disassembles a failure process into its component parts such that the overall process may be analyzed more easily. From such a breakdown the sources or causes of an actual failure may be more effectively determined or the most probable potential failure processes identified. Once an overall failure process, either actual or potential, has been defined and understood, remedial or preventive action may be taken more effectively. Such action

may include redesign, stricter quality control, a maintenance task, or a combination of these things.

**SP640;** 1982 October. 61-71. Kincaid, R. L.; Kincaid, W. S. **Mechanical systems integrity management.**

**Key words:** atomic emission spectroscopy; cost-effective; data processing; infrared spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry.

As mechanical systems have become more sophisticated and dependence upon them more absolute, increasingly complex problems have been generated for both maintenance and management. Maintenance of these systems no longer can be treated as an isolated technical activity, but must be a vital, integral part of the entire industrial management function. Modern analytical techniques are available for determining mechanical and lubricant integrity. When this information is organized and systematized into a program for the management of maintenance, it can provide constantly updated information as to required maintenance action as well as benchmarks against which to measure the effectiveness of maintenance operations, establish trends and evaluations for projections to the future, and provide an almost unlimited source of management information as related to the mechanical systems monitored.

**SP640;** 1982 October. 71-85. Johansson, K. E. **Field monitoring of NC-machines—A system approach.**

**Key words:** administrative system for maintenance; automatic condition monitoring; condition monitoring module; microcomputer.

In Sweden unmanned factories have become a reality. Condition monitoring (CM) of NC-machines becomes a vital concern in this type of factory and it is important that the monitoring system be integrated into the normal maintenance system of a factory. This paper addresses the following points: Which machine components need CM. Which system should be used for CM. Design of alarm systems both for a single machine and for an entire factory.

The investigations which have been carried out show that each machine is unique with regard to its specific alarm limits, set-points, etc. The measurements used in condition monitoring are not necessarily absolute since interest is focused on the changes that occur over a life span. When monitoring an entire factory one should avoid building the system around one centralized master computer since each machine must be accessible to separate monitoring independent of a central computer.

**SP640;** 1982 October. 86-112. Seddon, G. N. D.; Kelly, A. A. **Maintenance plan for a batch chemical plant.**

**Key words:** cost effectiveness; maintenance effectiveness; preventive maintenance plan; programmed inspections.

Many maintenance departments find themselves in one of two situations: either they are "fire-fighting," or they are over maintaining.

This paper presents a method of establishing a maintenance plan to overcome this problem. A dynamic model of the maintenance/production system is proposed as a background against which a systematic method for establishing a maintenance plan is developed. The method proposed uses a "top down" approach to analyse the maintenance requirements of a plant. Once determined, the requirements are synthesized into a maintenance plan. An example of the method as applied to a batch chemical plant is then given.

**SP640;** 1982 October. 115-129. Rio, R. A. **Improved engine maintenance through automated vibration diagnostic systems.**

**Key words:** balancing; diagnostics; faults; jet engines; monitoring; overhaul; productivity; vibration.

The rapidly increasing cost of maintenance, the demand for increased equipment utilization, fuel costs, and the difficulty of correctly diagnosing internal mechanical problems in fully



assembled jet engines, have stressed the need for more effective engine test equipment. This paper describes the successful application of a component (module) high-speed balancing technique developed for the U.S. Army for use at the Corpus Christi Army Depot and an Automated Vibration Diagnostic System (AVID) for the U.S. Air Force's engine overhaul center at Tinker Air Force Base, Oklahoma. The AVID concept to automate trouble-shooting procedures for fully assembled rebuilt engines is addressed. This system extracts high-frequency vibration data from existing standard instrumentation, thereby providing meaningful mechanical information. A growing appreciation on the part of engine overhaul personnel of the power of automated test equipment has enabled these key features to be combined to reduce operating expenses at engine rebuild facilities.

**SP640; 1982 October. 130-149. Pauze, D. E. Innovations in epicyclic gear system design for increased service life.**

**Key words:** bearing life; bearings; epicyclic system; gear train; planet bearings; planetary gears.

Current epicyclic gear systems in helicopter drive trains are designed for a non-catastrophic failure mode: surface fatigue. The sun and ring gears are loaded on one side of the gear teeth only, so that otherwise perfectly good gears are retired from service. With design innovations, the epicyclic gears can be made with fore and aft symmetry to perform double duty.

**SP640; 1982 October. 150-161. King, J. P.; Asmerom, Y.; Devine, M. J. Effect of antimony thioantimonate in greases on abrasive wear.**

**Key words:** abrasive wear; antimony thioantimonate; extreme pressure and antiwear properties; greases; solid lubricant additive.

There is a crucial need for effective lubricant additives that are capable of preventing damage that may occur due to contamination of lubricating systems by abrasive particles. This is an essential requirement for lubricants used in equipment and military vehicles that are operated in sandy environments. The effect of antimony thioantimonate ( $\text{SbSbS}_4$ ) in three base greases—MIL-G-10924, MIL-G-24139, and MIL-G-81322—was investigated. The presence of  $\text{SbSbS}_4$  in these greases provided considerable improvements in weld point, load wear index, and wear prevention properties with two different alloys. Moreover, impressive wear resistance properties were imparted by low concentrations of  $\text{SbSbS}_4$  in these greases deliberately contaminated with hard abrasive particles. The combination of outstanding EP and antiwear characteristics and anti-abrasion properties of antimony thioantimonate makes this material an attractive candidate as a grease additive. Extensive field testing of greases containing this material is recommended.

**SP640; 1982 October. 162-169. Holbrook, G. W. Silicone brake fluid: The answer to reduced maintenance and longer life!**

**Key words:** long life; reduced maintenance; silicone brake fluid; U.S. Army.

One of the most costly maintenance items in a motor vehicle is the hydraulic braking system. Studies by the Department of Transportation indicate that on an average the hydraulic braking components are replaced at least twice during the life of a vehicle at a cost of

A thirteen-year development and testing program involving the U.S. Army, the Department of Transportation, and the silicone industry has resulted in the development of silicone-based brake fluids. Extensive testing has demonstrated the superior performance of these fluids which give promise of providing a hydraulic system which will need no maintenance for the life of the vehicle, exclusive of friction materials.

**SP640; 1982 October. 170-186. Trainer, C.; Rokos, D. R. The requirement of lubrication systems in maintenance programs and new developments to enable more precise control.**

**Key words:** diagnostic controls; hydro-dynamic condition; lubrication systems; maintenance program; prevention.

The purpose of this paper is to examine the concept of lubrication in its use and to highlight developments which lead to more precise control and ensuring protection of costly moving parts which in turn leads to higher productivity.

**SP640; 1982 October. 187-193. Badger, P. O. Conceptual proposal for self-lubricating high carbon piston ring steel.**

**Key words:** carbide precipitation; decarburization zones; implantment by mechanical inclusion; macro-molecular clustering; molybdenum disulfide imbedment.

Molybdenum disulfide bonding to high carbon interstitial alloys utilized in the manufacture of piston rings is performed at an intermediate stage of the steel making process when voids existing between surface asperities are pronounced. Subsequent steps in the traditional steel making process impregnate the lubricant into the outer periphery of the cross-section by mechanical pressures. The alloy produced maintains the same physical properties such as yield strength and Rc hardness specified for piston ring stock but exhibits a sustaining self-lubricating characteristic of a bearing material.

**SP640; 1982 October. 194-196. Lanza, V. J. Thermal deposition systems for improved maintenance.**

**Key words:** aluminum non-skid coating; corrosion control; erosion; flame spray process; plasma coatings; thermal deposition systems; thermospray process; wear.

The military has a continuing need to improve the service life of its equipment. The Navy with its ships and shipboard equipment exposed to marine environment, as well as erosion and wear, has an everlasting requirement to keep its equipment in readiness. The Navy builds its ships to have a thirty (30) to forty (40) year service life. The latest designs of these ships are the DD963 Sprunce Class Destroyer and Frigate Class Ships. This paper will attempt to describe the applications implemented aboard ships of this class dealing with corrosion, erosion and wear. We will also attempt to describe the equipment, along with the application, and their respective economical advantages. The Navy being one of the forerunners using this process, is by no means the only one. The Army has implemented applications in its new gas turbine used in the XM1 Tank. In attempting to stress the use of the flame spray process, guidance is recommended. The new industry and program to be discussed in this paper will be the diesel rebuilt market and the applications already implemented by the original equipment manufacturer.

**SP640; 1982 October. 199-215. Smith, R. L.; Krauter, A. I. Simulation of track maintenance costs.**

**Key words:** computer simulation; life cycle costs; maintenance, track; Simulation Cost Model; track maintenance planning; track standards.

The Simulation Cost Model (SCM) provides economic evaluations for maintenance of systems, components, or assemblies. The application of this technique for costing maintenance operations of track and its component structures is described. Examples are provided which illustrate the use of maintenance action diagrams. These diagrams graphically represent the system being modeled.

The SCM procedure allows separate maintenance cost entries to be associated with definable track substructures such as rail, cross ties, or ballast. In this manner separate tabulations of maintenance expenditures can be obtained from the computerized technique. The SCM also allows time-dependent cost estimating and produces costs by year for: class of track, component or substructure repaired, type of maintenance operations, labor, material, equipment, delays, scrap, fines, etc.

The track SCM computer program is tailored specifically for track maintenance cost analysis, but user flexibility is built in and any maintenance operation which can be depicted through use of a "maintenance action" diagram can be analyzed.

**SP640; 1982 October. 216-221. Downing, W. D., Jr.; Pruett, J. P.; Winn, B. D. Automatic test system for reliability assessment of guided missile re-entry vehicles.**



**Key words:** automatic test system; computer-automated; re-entry vehicles; reliability assessment.

A computer-automated test system (ATS) to perform a system level test of guided missile re-entry vehicles (RV) for reliability assessment is being developed for use at Kelly AFB. The ATS is intended to replace the original test complex control system which has been in operation since 1968. During the test, the ATS will control flight environment equipment, deliver discrete signals to the RV and monitor output signals from the RV. Data acquired during the test is used for reliability scoring. This paper gives a brief description of the performance requirements and design solutions being implemented in the new ATS. Emphasis will be given to those areas in which major changes will be made in both hardware and software to take advantage of the experience gained over the several years of testing, as well as those required to provide additional testing capability. The final portion of the paper describes how the data acquired during the test is used in reliability assessment.

**SP640;** 1982 October. 222. Perra, S. Reduction of test equipment proliferation with third generation ATE.

**Key words:** ATE systems; calibration; computer; hardware; measurement; third generation ATE; third generation core system.

Conventional ATE systems use discrete test instruments to measure each parameter. Third generation ATE exploits the full computational capabilities of the system computer to evaluate test parameters by applying such techniques as Fast-Fourier transformers, digital filtering, statistical analysis, list sorting, and least-squares curve fitting. Hardware-associated errors such as those introduced by lead length, gain and offset, and A- to D-converter non-linearity are corrected automatically by calibration software routine on a sample-by-sample basis.

Similarly, the system also has the capability which allows the user to create complex stimulus waveforms using the computer. Thus, any number of waveform types (classical, complex or arbitrary waveforms) can be generated by computer algorithms.

This basic stimulus and measurements capability forms a third generation core system, which when augmented with special front-ends, such as hydraulic/pneumatic, electro-optical and motion, provides an optimum solution to meeting avionics testing requirements.

The result is less peculiar test stations with less measurement and stimulus hardware, and thus more reliability, less calibration, and more flexibility to meet future needs.

**SP640;** 1982 October. 223-234. Hartwell, R. E. The development of automated test procedures for complex electro-mechanical systems.

**Key words:** automated test equipment; fault isolation diagnostics; functional subsystem; line replaceable units; malfunction; microprocessor controlled test set; symptom; test strategy.

Systems which are partly mechanical and have significant electrical controls, drives and testing/monitor points are well suited to automatic testing. The use of a microprocessor controlled test system permits improved test strategy, with sophisticated measurement processing, rapid test step execution, and program controlled interactive messages to the mechanic. This paper discusses design methods and techniques which lead to improved tests. The turret stabilization and fire control system of a modern combat vehicle are used in an example of automated test development for complex, interactive, electro-mechanical systems. Quantitative and qualitative techniques are presented, as used in developing test strategies for that vehicle, and for evaluating the effectiveness of the test programs and their validation in actual fault isolation exercises.

**SP640;** 1982 October. 235-254. Pohlenz, H. E. Advanced attack helicopter AH-64 fault detection/location system.

**Key words:** Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE);

**Skill Performance Aids (SPA).**

Army and Hughes Helicopters Advanced Attack Helicopter (AH-64) Program Management have stressed the importance of an effective Fault Detection and Location System (FD/LS) throughout the AH-64 design process. The FD/LS program objectives were to avoid flights with failed safety and mission critical hardware, reduce maintainability downtime and prevent removal and replacement of good hardware. The design approach was to make extensive use of existing AH-64 equipment with Built-in Test Equipment (BITE) added, and to emphasize reliability and maintainability techniques, analyses and tradeoff processes from the earliest stages of the design effort. The resulting AH-64 FD/LS is an optimum mix of hardware (conventional caution and warning devices coupled with microprocessor controlled multiplexing system for data handling and display), Man-in-the-Loop systems operations, and technical procedures and maintenance manuals. Both AH-64 FD/LS test and analysis results indicate that systems objectives and requirements have been met or exceeded.

**SP640;** 1982 October. 257-274. Guyer, R. A., Jr. Service life of bearings can be increased with "proper maintenance".

**Key words:** corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling.

Many times a bearing sees only 10 to 20 percent of its calculated life due to such life shortening factors as: poor shaft and housing fits; improper installation; inadequate lubrication; dirt and water intrusion. When a bearing failure occurs it is of primary importance to be able to determine what caused the failure in order to prevent future failures.

On many occasions a bearing will be replaced without checking the shaft and housing fits and the condition of the failed bearing and as a result still another bearing will fail because the inherent deficiency in the previous installation was not properly diagnosed.

**SP640;** 1982 October. 275-289. Lootens, H. T. The application of nylon powder coating to vehicular components.

**Key words:** battery-acid corrosion; metal coating; polymer coating; rust prevention; vehicular rust.

Rust causes serious damage to vehicles, especially in a salt-air environment. Also, leakage or spillage of battery acid causes significant corrosion of battery-related components. Another type of corrosion occurs inside fuel filler sleeves of diesel-fueled vehicles. This corrosion deposit (lead carbonate), formed by the interaction of the fuel, moisture and the lead coating on the sleeve, can cause major problems in the vehicle fuel injection system. Approximately 1500 vehicular parts were coated with Nylon 11 to evaluate its effectiveness in the prevention of rust and corrosion. These parts included battery boxes, trays and frames, as well as fuel sleeves and frames. The characteristics and properties of Nylon 11 are summarized, the coating facilities and procedures are described and recommendations are presented.

**SP640;** 1982 October. 290-294. Bennett, M. K.; Ravner, H. Alternative antistatic packaging materials for precision bearings.

**Key words:** antistat-bearing steel interaction; antistatic agents; antistat-lubricant interaction; bearing packaging materials; bearing steel wettability; lubricant displacement; precision instrument bearings.

Precision instrument bearings currently are packaged in polyethylene or nylon films containing minor amounts of antistatic agents. A previous NRL study showed that the presently used surface-seeking antistatic agents adversely affect the contacting bearing metal surface and/or bearing lubricant. To ameliorate these problems, the following alternatives were investigated: 1) chemically characterized antistatic agents either incorporated into or topically applied to the polymer films; 2) alternate packaging materials. Effects of exposure of these alternatives to pure lubricants, lubricated steel surfaces, and clean steel surfaces were examined. The results provided information



on possibly deleterious transfer of the antistatic agent to any contacting surface affecting lubricant properties and surface wettability.

**SP640;** 1982 October. 295-325. Reason, B. R.; Schwarz, V. A. **A thermal prediction technique for extending in-service life of roller bearing assemblies.**

**Key words:** bearing failure; bearing reliability; condition monitoring; roller bearings; thermal analysis.

A programme is described involving the measurement of spacial temperatures in a rolling contact bearing assembly. A technique of thermal analysis, amenable to computer programming, is presented and the results from this compared with the experimental findings. The paper concludes with a discussion on the temperature correlation obtained and the thermal factors influencing premature bearing failure.

**SP640;** 1982 October. 326-347. Bhachu, R.; Sayles, R.; Macpherson, P. B. **The influence of filtration on rolling element bearing life.**

**Key words:** filtration; gearboxes; helicopter transmission; pitting; rolling element bearings; rolling fatigue; spalling.

Using a gear machine to generate debris, which had been verified by Ferrographic analysis as being representative of that found in helicopter gearboxes, contaminated oil was passed through filters of different sizes before being fed into a parallel roller bearing fatigue machine. In-line particle counting monitored the debris content of the oil which was based on a helicopter type of lubricant. Filter sizes ranged between 1 and 40  $\mu\text{m}$  absolute ratings and submicronic extraction was achieved by using electro-magnetic filtration. Bearing fatigue tests were run, under constant operating conditions, for all filter ratings and Weibull lines were drawn based on a minimum sample size of 10 failures. From these a relationship between filter rating and fatigue life was established. The experimental program is described and results discussed.

**SP640;** 1982 October. 348-363. Rebuck, N.; Stallings, L. **Improved instrument bearing lubrication.**

**Key words:** aircraft hydraulic fluid; aircraft wheel bearing grease; instrument bearing lubrication; low temperature fluidity; synthetic hydrocarbon oils.

This paper will present the results of laboratory tests on three viscosity grades of synthetic hydrocarbon oils for the purpose of providing proposed specification requirements to cover these oils for military instrument bearing applications.

Synthetic hydrocarbon oils (fabricated from L. Olifins) have become increasingly more popular in the last decade. The initial widespread use of one such type fluid was as a base oil in a grease covered by Military Specification MIL-G-81322 which was originally developed for use in aircraft wheel bearings. This was followed by the use of a lower viscosity grade oil as an aircraft hydraulic fluid covered by Military Specification MIL-H-83282. Today both the grease and the hydraulic fluid are high volume items in the Navy Supply System. The grease is currently being used in a wide variety of military weapons systems applications including instrument bearings.

Interest in these fluids has also expanded to the industrial and commercial markets. Formulated fluids are available as multi-purpose gear lubricants, automotive engine oils, gas turbine lubricants, and high temperature bearing lubricants. Some of the major attributes of the oils include: (1) their high viscosity index, (2) their good thermal stability, (3) receptiveness of common additives and inhibitors, (4) their low temperature fluidity and (5) their compatibility with other lubricants and materials. Still another attractive feature is the outlook for their long term availability, an aspect which is of considerable interest to the instrument bearing community.

**SP640;** 1982 October. 364-378. Caravaso, N. **Advanced structures maintenance technology.**

**Key words:** composite materials; laminate structure; maintenance;

repairability; sandwich structure; testing.

The use of composites in aircraft structures has been increasingly evident in the last decade as the drive for lower cost, lighter weight, more reliable aircraft structure has intensified. Composite structural systems are meeting these challenges and their use is being accepted and is expected to expand in the future. New hybrid constructions where materials such as graphite are integrally fabricated with fiberglass or Kevlar designs to control stiffness and provide fail safety while maintaining high strength to weight ratio will require unique repair and quality control methods.

This paper (a) summarizes the state-of-the-art in structural repair and maintenance of advanced composite structures, (b) identifies technological gaps, and (c) outlines a development and test program to fill in these technological gaps.

**SP640;** 1982 October. 379-399. Carrato, A. F.; DeLong, G. E.; Shaffer, I. S. **Design guidelines for avionic corrosion prevention and control.**

**Key words:** avionic component design; avionic corrosion damage; corrosion damage; equipment design failures; marine environmental factors; moisture intrusion in avionic equipment.

There is evidence that moisture intrusion currently is the largest single cause of Navy avionic (airborne electronic) equipment becoming non-operational while installed in carrier aircraft. The basis of this failure mode includes not only the general severity of the naval marine environment, but particularly the intrusiveness of the chloride-ion laden moisture that permeates the interior of the aircraft—including entering equipment housings, connectors and almost all areas generally considered to be "protected." Equipment designed for optimum electrical performance during the time it is operating can be particularly vulnerable to corrosion during the other 95% of the time when it is in a static, non-operating condition. Fundamental to the continuing nature of the design characteristics that permit such equipment deterioration is the lack of feedback information on fleet failure modes to the original equipment designer. Seldom is the original design engineer appraised of the design-induced problems he had created several years previously. Understandably, therefore, he incorporates the same design characteristics in his following assignments.

**SP640;** 1982 October. 417-453. John, J. **The role of neutron radiography in a maintenance environment.**

**Key words:** composite inspection; corrosion detection; cost savings; NDE; neutron radiography; preventive maintenance.

Neutron radiography is similar to x-ray inspection in that both depend upon use of radiation that penetrates some materials and is absorbed by others to provide a contrast image of conditions not readily available for visual inspection. But an important difference is the type of materials that absorb each of the two kinds of radiation. X-rays are absorbed by dense materials, such as metals, whereas neutrons readily penetrate metals but are absorbed by materials containing hydrogen.

The neutron radiography technique has been successfully applied to a number of inspection situations. These include the inspection of explosives, advanced composites, adhesively bonded structures and a number of aircraft engine components. With the availability of Californium-252, it has become feasible to construct mobile neutron radiography systems suitable for field use. Such systems have been used for *in situ* inspection of flight line aircraft, particularly to locate and measure hidden corrosion.

**SP640;** 1982 October. 454. Sarian, S. **CREG<sup>TM</sup> eddy current NDE: A cost effective approach to failure prevention.**

**Key words:** defect detection; eddy current; failure prevention; ferro-magnetic alloys; inspection; metal distress; metal parts; NDE; nickel base alloys; testing.

State-of-the-art NDE practice for quality assurance and failure prevention relies basically on magnetic particle/penetrant, ultrasonic, and conventional eddy current techniques. Of these techniques, eddy current is the most attractive because it is versatile and can be applied to a wide spectrum of NDE problems—defect detection and sizing, coating thickness



measurement, determination of heat treat/metallurgical condition such as hardness profile, dimensional measurement, to name a few—and it is especially amenable to rapid testing and screening of metal parts under production line conditions. In spite of its attractiveness, eddy current has not found widespread use because it suffers from edge effect which greatly reduces the effectiveness of the inspection in the vicinity of geometric tight spots, as well as lack of sensitivity, especially in the inspection of low conductivity titanium and nickel base alloys, and ferromagnetic alloys because of problems with high background noise. Therefore, improvements in eddy current inspection performance are necessary to assure reliable micro-examination of materials and to avoid confusing the inspection because of false signals arising from material artifacts not conducive to the mechanical integrity—especially in production and maintenance environments.

There are three complimentary areas where improvements in early detection, identification, and sizing of metal distress can be made: (1) in the sensing element, (2) in the eddy current test instrumentation, and (3) in the signal data processing. It has been Reluxtrol's experience that the first of these areas is subject to greatest improvement in inspection performance. In this paper we describe the high-sensitivity, high resolution CREG<sup>TM</sup> focused field eddy current sensors and ancillary electronics to accomplish inspection of a wide variety of test parts under production line and field maintenance conditions.

**SP640;** 1982 October. 455-465. Hillan, W. J.; Ross, W. D.; Eisentraut, K. J. *Design and development of a colorimetric field test kit for iron wear metal determination.*

**Key words:** colorimetric iron kit; iron; jet engine oil; portable; rapid; wear-metal analysis.

A rapid, flight-line kit for the analysis of iron wear metal (a major wear indicator) in jet engine lubricants has been developed by Monsanto Research Corporation in conjunction with the U.S. Air Force. The Colorimetric Iron Kit (CIK) was developed to reduce the analytical lag time caused by sending all lubricating oil samples to an Air Force Oil Analysis Program (AF-OAP) laboratory. The CIK is portable, compact, light weight (25 pounds), and can be operated by nontechnical personnel.

The kit utilizes a colorimetric method which employs a solvent extraction-chelation procedure. Reagents required for the procedure are sealed in plastic tubes and along with all disposable items are packaged in analysis packets which are contained in the Colorimetric Iron Kit. The colored solution resulting from the analysis procedure is quantitated with a spectrophotometer.

A Hach DR/2 spectrophotometer has been modified to meet the specific requirements of the CIK. The required wavelength is preset and the meter scale reads directly in parts-per-million iron. Designed to analyze concentrations between 0 and 50 ppm iron, the kit contains all required components in a 23.5×10×8.5 inch carrying case.

Six kits and 1,500 analysis packets were successfully field tested by the Air Force in the United States. Currently six kits and 2,000 analysis packets are being tested by the U.S. Air Force in Europe.

**SP640;** 1982 October. 466-475. Senholzi, P. B. *Ferrography standardization.*

**Key words:** diagnostics; ferrography; health monitoring; tribology; wear; wear debris analysis.

Wear particle technology is a recent development in the equipment wear field. This technology is based on the analysis of wear debris as a nondestructive reflection of the surface wear condition of the respective monitored wear process. This monitoring approach can be applied to everything from simple wear testing to sophisticated multicomponent wear systems. Wear particle analysis technology is rapidly establishing itself as a valuable tool in both the wear prevention and wear control arenas.

Ferrographic analysis is a relatively new approach to the analysis of wear debris. Until recently, this technique has been utilized as a research tool in a limited number of laboratory facilities. However, as a result of initial successful utilization, ferrographic technology is receiving ever increasing interest.

This increasing interest level has raised serious questions with respect to standardization and repeatability.

This paper describes an effort to quantify and apportion analytical ferrography repeatability/nonrepeatability. Under a program sponsored by the Office of Naval Research, four leading laboratories contributed controlled ferrographic analysis data. This data has been analyzed and the resulting repeatability/nonrepeatability assessed with respect to analysis variables.

**SP640;** 1982 October. 495-504. Lee, W. W. *Improving maintenance manpower utilization.*

**Key words:** breakdown maintenance; labor problems; maintenance; management support; manpower utilization; worker productivity.

Managing the Maintenance function is extraordinarily difficult. Many factors contribute to this difficulty. Labor problems are complex because of craft lines. Efficiency is hard to achieve. It is difficult to schedule men and materials to jobs because of the constant interruption of emergencies. Overtime is commonly too high. Foreman usually are inadequately trained and receive little management support. The most difficult problem may be that of developing management understanding of the methods of maintenance cost control and an organization that desires and is able to control maintenance costs.

**SP640;** 1982 October. 476-494. Agarwala, V. A *continuous corrosivity monitoring device for the marine environments.*

**Key words:** alternate immersion; corrosivity monitoring device; exposure tests; marine environments; salt fog.

Currently the assessment of corrosivity of an environment is made on the projected figures obtained on a cumulative basis from outdoor, longterm exposure tests. Tests such as salt fog, total or alternate immersion, are primarily designed from such projections to produce an accelerated laboratory test environment. Although these test methods have been quite successful in evaluating various materials, they are too often indiscriminately used. In situations where rapid weather changes control the nature of the environment or the locations are inaccessible, a true evaluation of the corrosivity of the environment is not possible. Any extrapolation of the results obtained from laboratory tests may be inaccurate at best, and deceptive, at worst.

**SP641.** Franzen, D. L.; Day, G. W.; Gallawa, R. L., eds. *Technical digest—Symposium on optical fiber measurements, 1982.* Digest of a Symposium sponsored by the National Bureau of Standards in cooperation with the IEEE Transmission Systems Subcommittee on Fiber Optics (COMMSOC) and the Optical Society of America; 1982 October 13-14; Boulder, CO. *Natl. Bur. Stand. (U.S.) Spec. Publ. 641;* 1982 October. 156 p. SN003-003-02411-2.

**Key words:** attenuation; bandwidth; fiber optic joints; fiber optics; fiber optics-single mode; index profile; measurements.

This volume contains summaries of papers presented at the Symposium on Optical Fiber Measurements held October 13-14, 1982, at the National Bureau of Standards in Boulder, Colorado. Subjects include the measurement of attenuation, bandwidth, index profile/geometry, joint/defect, and single mode fibers. Also included are applied/field measurements and standards. *These proceedings include the following papers (indented):*

**SP641;** 1982 October. 1-7. Reitz, P. R. *Prediction of length performance of multimode graded-index fiber.*

**SP641;** 1982 October. 9-12. Wright, J. V.; Nelson, B. P. *Bandwidth studies of concatenated multimode fibre links.*

**SP641;** 1982 October. 13-16. Blackmore, R. W.; Batty, N. G. *Determining the concatenated dispersion of multimode fibres.*

**SP641;** 1982 October. 17-19. Bouillie, R.; Bizeul, J. C. *Is the -6 dB bandwidth fiber selection criterion still valid?*

**SP641;** 1982 October. 21-24. Nishimura, M.; Suzuki, S.



Investigation on launching conditions in the bandwidth measurement of graded-index fibers.

SP641; 1982 October. 25-28. Stone, F. T. Results of a Bell system bandwidth measurement round robin.

SP641; 1982 October. 29-32. Saito, J.; Oki, T.; Yamamoto, H. Wavelength dispersion measuring equipment.

SP641; 1982 October. 33-36. Buckler, M. J. Measurement of bandwidth versus impulse response width in multimode fibers.

SP641; 1982 October. 37-42. Szentesi, O. I. Field measurements of fiber optic cable systems.

SP641; 1982 October. 43-46. Short, L. S.; Kummer, R. B. Improved automated loss set for optical cables.

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SP641; 1982 October. 51-54. Matsui, K.; Tanaka, S.; Hoshikawa, M. Precise measurement of optical fiber breaking elongation.

SP641; 1982 October. 55-58. Vella, P. J.; Abe, K.; Kapron, F. P. Precise measurement of steady-state fiber attenuation.

SP641; 1982 October. 59-62. Agarwal, A. K.; Karstensen, H.; Unrau, U. Modal behavior of various mode mixers and mode filters for optical fiber measurements.

SP641; 1982 October. 63-66. Eriksrud, M.; Mickelson, A. R.; Lauritzen, S.; Ryen, N. Influence of differential mode attenuation on backscattering attenuation measurements.

SP641; 1982 October. 67-70. Kashyap, R.; Pantelis, P. Measurement of optical fibre absorption loss: A novel technique.

SP641; 1982 October. 71-77. Nosu, K. Single-mode fiber measurement in Japan.

SP641; 1982 October. 79-84. Stern, J. R.; Payne, D. B.; Wood, T. D. S.; Todd, C. J. The characterization of monomode fibre links installed in operational duct.

SP641; 1982 October. 85-87. Gardner, W. B. Single mode fiber loss round robin.

SP641; 1982 October. 89-92. Tomita, A.; Glodis, P. F.; Kalish, D.; Kaiser, P. Characterization of the bend sensitivity of single-mode fibers using the basket-weave test.

SP641; 1982 October. 93-96. Fox, M. Calculation of equivalent step-index parameters for single-mode fibres.

SP641; 1982 October. 97-100. Wang, C. C.; Villarruel, C. A.; Burns, W. K. Comparison of cutoff wavelength measurements for single mode waveguides.

SP641; 1982 October. 101-104. Barlow, A. J.; Payne, D. N. Measurements of fibre polarisation properties using a photo-elastic modulator.

SP641; 1982 October. 105-108. Hornung, S.; Reeve, M. H. Measurements of strain in cabled monomode fibre.

SP641; 1982 October. 109-121. Kummer, R. B.; Judy, A. F.; Cherin, A. H. Field and laboratory transmission and OTDR splice loss measurements of multimode optical fibers.

SP641; 1982 October. 123-126. Kaiser, P.; Young, W. C.; Curtis, L. Optical connector measurement aspects, including single mode connectors.

SP641; 1982 October. 127-130. Marchesi, C.; Rossi, U. Effects of mode filter insertion on connection loss between commercial single-fibre cables.

SP641; 1982 October. 131-134. Jeffery, R. D.; Hullett, J. L. A new approach to joint loss measurement.

SP641; 1982 October. 135-138. Stewart, W. J. Index profile measurements.

SP641; 1982 October. 139-142. Ridgway, D. N.; Freeman, L. J. A simple technique for high accuracy core-cladding concentricity measurement of single mode fibers.

SP641; 1982 October. 143-146. Kim, E. M.; Franzen, D. L. An interlaboratory measurement comparison of core diameter on graded-index optical fibers.

SP642. Ondik, H. M.; Christ, B. W.; Perloff, A. Construction materials for coal conversion. Performance and properties data. *Natl. Bur. Stand. (U.S.) Spec. Publ. 642*; 1982 September. 826 p. SN003-003-02442-2.

Key words: alloys; coal conversion; coal gasification; corrosion; erosion; materials properties; mechanical properties; physical properties; refractories.

This book, *Construction Materials for Coal Conversion—Performance and Properties Data*, provides a central source of materials information needed for the fossil fuel industry. Data have been collected and evaluated from Department of Energy-sponsored projects. The focus is on construction materials for coal gasification use. The book is organized so that the information is given both with respect to the various component areas of a coal gasification plant and with respect to the properties or possible failure mechanisms, e.g., corrosion, erosion, mechanical properties, and physical properties.

## 5.7 APPLIED MATHEMATICS SERIES

Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

No publications issued in this series during this period.



## 5.8 NATIONAL STANDARD REFERENCE DATA SERIES

Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS. Program under the authority of National Standard Data Act (Public Law 90-396).

**NSRDS-NBS61, Part V.** Ledbetter, H. M. **Physical properties data compilations relevant to energy storage. V. Mechanical properties data on alloys for use in flywheels.** *Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 61, Pt. V*; 1982 January. 42 p. Available from: NTIS; PB 82-232919.

Key words: alloy; aluminum alloy; elastic constants; flywheel; iron alloy; mass density; mechanical property; titanium alloy.

This report deals with the physical and mechanical properties of twenty-one commercial alloys that are candidates for flywheel rotors used as inertial-energy-storage systems. Base metals include aluminum, iron, and titanium. Alloys vary in complexity from simple carbon steels to superalloys. Properties include: mass density, Young's modulus, shear modulus, bulk modulus, Poisson's ratio, yield strength, ultimate strength, fatigue strength, fracture toughness, and creep strength. Property values were collected from many types of sources and were analyzed statistically to detect possible outlying values. For each alloy, the report contains typical chemical composition, typical heat treatment, metallurgical descriptions, and typical property values. The report also shows the variations of these properties and the relative abundances of experimental property values.

**NSRDS-NBS70.** Ross, A. B.; Neta, P. **Rate constants for reactions of aliphatic carbon-centered radicals in aqueous solution.** *Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 70*; 1982 October. 103 p. SN003-003-02431-7.

Key words: alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates.

Rate constants have been compiled for reactions of various transient aliphatic radicals produced mostly by radiolysis in aqueous solutions. In certain cases the radicals have been produced by photolysis or by a thermal chemical reaction. Data are included for aliphatic carbon-centered radicals only, i.e., substituted alkyl radicals in the broad sense, but not for oxyl or aminyl radicals. Reactions of the aliphatic radicals with inorganic and organic compounds are included.

**NSRDS-NBS71.** Levin, R. D.; Lias, S. G. **Ionization potential and appearance potential measurements, 1971-1981.** *Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 71*; 1982 October. 634 p. SN003-003-02424-4.

Key words: appearance potential; charge transfer spectrum; electron impact ionization; ionization potential; photoelectron spectroscopy; photoionization; spectroscopy.

A compilation is presented of the ionization potential and appearance potential measurements which appeared in the refereed literature in the time period 1971-1981. The data are sorted according to the identity of the ionic species formed in the ionization process. Precursor molecules or radicals are identified by a structural formula and, in the case of compounds containing rings, by name according to the Chemical Abstracts system of nomenclature. Chemical Abstracts Registry Numbers are provided where available. A complete bibliography and author index are provided.

**NSRDS-NBS72.** Westley, F. **Tables of rate constants for gas phase chemical reactions of sulfur compounds (1971-1980).** *Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 72*; 1982 May. 42 p. Available from: NTIS; PB 82-215401.

Key words: Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur.

A table of rate constants for gas phase chemical reactions of sulfur compounds is presented. Specifically, it gives in tabular form the values of the parameters for the modified Arrhenius equation  $k = AT^b \exp(-E/RT)$ . The table covers the reactions of sulfur containing molecules and free radicals, S, S<sub>2</sub>, SO, SO<sub>2</sub>, SO<sub>3</sub>, S<sub>2</sub>O, SH, H<sub>2</sub>S, CS, CS<sub>2</sub>, COS, CH<sub>3</sub>S, CH<sub>3</sub>SH, cy-CH<sub>2</sub>CH<sub>2</sub>S, CH<sub>3</sub>SCH<sub>2</sub>, and a number of thiols, thioethers, and thioesters, with other compounds. The table includes 19 unimolecular, 208 bimolecular, and 13 termolecular reactions totaling 240 distinct chemical reactions. There are 441 rate constants associated with these reactions, distributed as follows: 30 for first order reactions, 377 for second order reactions, and 34 for third order reactions. The kinetic data were compiled from 145 experimental papers and 8 critical reviews published between 1971 and 1980.



## 5.9 BUILDING SCIENCE SERIES

Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

**BSS137.** Gujral, P. S.; Clark, R. J.; Burch, D. M. **An evaluation of thermal energy conservation schemes for an experimental masonry building.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 137*; 1982 July. 39 p. SN003-003-02401-5.

**Key words:** building thermal mass; dynamic performance of buildings; energy conservation; heat transfer in buildings; night space cooling; night ventilation; passive solar heating.

A one-room masonry building with exterior polystyrene rigid board insulation was built within a large environmental chamber at the National Bureau of Standards. Various climatic conditions were simulated within the chamber, and the transient thermal response of the test building was monitored. Three schemes (night cooling using a ceiling-mounted valance cooling coil, natural ventilation night cooling, and passive solar heating) were investigated with regard to energy conservation. The test results indicated that these operating practices resulted in a considerable reduction in energy consumption for space heating and cooling.

The measured performance of the test building compared favorably with the corresponding performance obtained with an analytic model.

**BSS138.** Dobry, R.; Ladd, R. S.; Yokel, F. Y.; Chung, R. M.; Powell, D. **Prediction of pore water pressure buildup and liquefaction of sands during earthquakes by the cyclic strain method.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 138*; 1982 July. 168 p. SN003-003-02412-1.

**Key words:** cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability.

A cyclic strain approach for evaluating the buildup of excess pore water pressures and the potential for liquefaction of level sandy sites during earthquakes is proposed in this report. This strain approach is based on the premise that, for undrained loading of sand, there is a predictable correlation between cyclic shear strain and excess pore water pressure; also, that there is a threshold shear strain below which there is no sliding at the contacts between sand particles and no pore water pressure buildup can occur. As the result, a sand deposit will not develop excess pore pressures if the induced seismic shear strain is less than the threshold strain. Both theoretical evidence and experimental verification supporting the cyclic strain approach and the existence of the threshold, are presented in the report. Based on all these findings, a specific design method is proposed for predicting if excess pore pressures will develop at a specific site during a design earthquake.

**BSS139.** Swaffield, J. A. **Application of method of characteristics to model the transport of discrete solids in partially-filled pipe flow.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 139*; 1982 February. 116 p. Available from: NTIS; PB 82-237405.

**Key words:** computer based model; drainage; solid transport; unsteady flow.

The flow depth and velocity changes across a moving solid in partially-filled pipe flow are predicted by means of the application of the method of characteristics to solve the unsteady flow equations.

Simplified force models are presented which, when used in conjunction with empirical relationships linking leakage flow past the solid to upstream specific energy, are sufficient to provide the required moving solid boundary conditions that allow solid velocity prediction.

A wide range of simulated transport conditions are presented that confirm the applicability of this technique as a basis for the future evaluation of more complex body force models.

The predicted solid velocity during drain transport is shown to be compatible with laboratory observations of the influence of solid dimensions and position in inflow profile on transport characteristics.

**BSS140.** Fanney, A. H.; Thomas, W. C.; Scarbrough, C. A.; Terlizzi, C. P. **Analytical and experimental analysis of procedures for testing solar domestic hot water systems.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 140*; 1982 February. 158 p. SN003-003-02387-6.

**Key words:** ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; NBS; solar; solar domestic hot water system; stratification; test method.

A repeatable test method independent of outdoor environmental conditions and laboratory geographical location is required in order to provide a means by which solar domestic hot water systems may be rated and compared. Three experimental techniques which allow the net thermal output of an irradiated solar collector array to be reproduced indoors without the use of a solar simulator are investigated. These techniques include use of an electric heat source only, use of a nonirradiated collector array in series with an electric heat source, and the use of electric strip heaters which are attached to the back of nonirradiated absorber plates. Expressions are developed to compute the input power required for each experimental technique. Solar collectors connected in parallel and series combinations are considered.

All three test techniques were shown to reproduce the outdoor daily collector array thermal output within four percent. Two of the techniques allow the actions of the circulator controller for an outdoor irradiated system to be duplicated indoors. One technique applies to solar hot water systems which operate on the thermosyphon principle.

Experiments conducted to determine the effect of storage tank temperature stratification on system performance for a single-tank direct solar hot water system are described. Several return tube designs, which introduce the solar heated water into the storage tank, were fabricated and tested to determine the influence of thermal stratification on system performance. The best return tube design increased the performance of the single-tank direct system approximately ten percent compared to a conventional return tube design.

An analytical model for a single-tank direct hot water system is developed. The model is used to support parametric studies for the thermal performance characteristics which result from the use of each test method to duplicate the net thermal output of an irradiated array. The model is also used to assess thermal performance differences which occur due to indoor versus outdoor environmental conditions.

**BSS141.** Collins, B. L. **The development and evaluation of effective symbol signs.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 141*; 1982 May. 96 p. SN003-003-02398-1.

**Key words:** communication; design issues; hazard; pictograms; pictorial; safety; signs; standards; symbols; visual alerting; warning.

Graphic symbols have recently been widely adopted for sign systems in the United States. Beginning with traffic sign systems, symbols have become widely used for applications ranging from products to buildings. In this report a brief history of the development of symbols is given, followed by a review of research on experimental evaluation of symbols. Some of the general advantages and limitations of symbols are discussed, along with graphic considerations essential in the development of effective symbols. Research on symbols for five areas of application—highway, automotive/machinery, public information, product hazard, and safety—is then discussed.

Finally, issues in the research and development of more effective symbols are reviewed. These include the need for good graphic design, characteristics of the intended user group, use of shape and color to encode information, and general visibility considerations.

**BSS142.** Yokel, F. Y.; Chung, R. M.; Rankin, F. A.; Yancey, C. W. C. **Load-displacement characteristics of shallow soil anchors.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 142*; 1982 May. 163 p. SN003-003-02394-9.

**Key words:** anchors; cyclic loading; field testing; flood forces; foundations; load capacity; mobile homes; soil anchors; soil mechanics; stiffness; wind forces.



Tests on shallow soil anchors, commonly used by the mobile home industry, including 6-in single helix and 4-in double helix anchors as well as three types of swivel anchors, were conducted on three sites: a silty site, a sandy site, and a clay site. Test variables included direction of anchor installation; direction of loading; anchor depth; size of anchor plate; and cyclic load effects. The effect of these test variables on load-displacement characteristics, measured at the anchor head, is investigated. It is concluded that on most sites the anchor types tested, when installed in accordance with present industry practice for mobile home tiedown systems, did not deliver the anchor performance required in present standards. It is recommended that minimum load capacity requirements for anchors be waived; that all anchors be preloaded to 1.25 times the design load; and that one anchor per mobile home, or three anchors per site if soil conditions are uniform, be preloaded to 1.5 times the design load.

**BSS143.** Marshall, R. D.; Pfrang, E. O.; Leyendecker, E. V.; Woodward, K. A.; Reed, R. P.; Kasen, M. B.; Shives, T. R. *Investigation of the Kansas City Hyatt Regency walkways collapse. Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 143; 1982 May. 360 p. SN003-003-02397-3.*

**Key words:** building; collapse; connection; construction; failure; steel; walkway.

An investigation into the collapse of two suspended walkways within the atrium area of the Hyatt Regency Hotel in Kansas City, Mo., is presented in this report. The investigation included on-site inspections, laboratory tests and analytical studies.

Three suspended walkways spanned the atrium at the second, third, and fourth floor levels. The second floor walkway was suspended from the fourth floor walkway which was directly above it. In turn, this fourth floor walkway was suspended from the atrium roof framing by a set of six hanger rods. The third floor walkway was offset from the other two and was independently suspended from the roof framing by another set of hanger rods. In the collapse, the second and fourth floor walkways fell to the atrium floor with the fourth floor walkway coming to rest on top of the lower walkway.

Based on the results of this investigation, it is concluded that the most probable cause of failure was insufficient load capacity of the box beam-hanger rod connections. Observed distortions of structural components strongly suggest that the failure of the walkway system initiated in the box beam-hanger rod connection on the east end of the fourth floor walkway's middle box beam.

Two factors contributed to the collapse: inadequacy of the original design for the box beam-hanger rod connection which was identical for all three walkways, and a change in hanger rod arrangement during construction that essentially doubled the load on the box beam-hanger rod connections at the fourth floor walkway. As originally approved for construction, the contract drawings called for a set of continuous hanger rods which would attach to the roof framing and pass through the fourth floor box beams and on through the second floor box beams. As actually constructed, two sets of hanger rods were used, one set extending from the fourth floor box beams to the roof framing and another set from the second floor box beams to the fourth floor box beams.

Based on measured weights of damaged walkway spans and on a videotape showing occupancy of the second floor walkway just before the collapse, it is concluded that the maximum load on a fourth floor box beam-hanger rod connection at the time of collapse was only 31 percent of the ultimate capacity expected of a connection designed under the Kansas City Building Code. It is also concluded that had the original hanger rod arrangement not been changed, the connection capacity would have been approximately 60 percent of that expected under the Kansas City Building Code. With this change in hanger rod arrangement, the ultimate capacity of the walkways was so significantly reduced that, from the day of construction, they had only minimal capacity to resist their own weight and had virtually no capacity to resist additional loads imposed by people.

**BSS144.** Crenshaw, R.; Clark, R. E. *Optimal weatherization of low-income housing in the U.S.: A research demonstration project. Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 144; 1982 September. 166 p. SN003-003-02437-6.*

**Key words:** Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption;

optimal weatherization; residential energy consumption; weatherization.

This report describes and presents the results of the Community Service Administration's (CSA's) Optimal Weatherization Demonstration Research Project carried out by the National Bureau of Standards (NBS). The CSA/NBS demonstration installed both architectural (building shell) and mechanical systems building weatherization options, and achieved, when both types of options were used, an average reduction in space heating fuel consumption of 41 percent, at an average weatherization cost of \$1862 per house.

The report explains the rationale used for selecting a sample of more than 200 houses at 12 sites across the United States, and for selecting optimal levels of weatherization for each of the houses. It presents measured energy consumption and detailed descriptive data on the houses before and after weatherization, the percentage savings achieved, and shows the costs of infiltration, conduction, furnace and water heater retrofits. Finally, it reports what options actually were installed in each house, and describes how data on the performance of those options were gathered and analyzed.

**BSS145.** Lew, H. S.; Carino, N. J.; Fattal, S. G.; Batts, M. E. *Investigation of construction failure of Harbour Cay condominium in Cocoa Beach, Florida. Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 145; 1982 August. 135 p. SN003-003-02405-8.*

**Key words:** building; collapse; concrete; concrete strength; construction; failure; flat plate; shear; strength.

The investigation of the collapse of a five-story reinforced concrete flatplate structure under construction at Cocoa Beach, Florida is presented in this report. The investigation included onsite inspection, laboratory tests and analytical studies.

Based on the results of this investigation, it is concluded that the most probable cause of the failure was insufficient punching shear capacity in the fifth-floor slab to resist the applied construction loads.

Two factors contributed to the low punching shear capacity, one in the design stage and the other in the construction stage. In the design, the omission of a check for punching shear resulted in a smaller slab thickness than needed to satisfy the Code requirements. In construction, the use of specified chairs having insufficient height to support the top reinforcing steel resulted in more than the cover specified in the structural drawings. Both factors contributed to reducing the effective depth of the slab such that it had insufficient strength to resist the construction loads.

The analysis showed that shear stresses in the slab at many column locations on the fifth floor exceeded the nominal shear strength. Thus, punching shear failure at one of the columns precipitated a progressive failure of the slab throughout the entire fifth floor. Collapse of the fifth floor, in turn, caused the successive collapse of the lower floor slabs. The analysis of the structure indicated that the failure of the fifth floor slab most likely initiated at column G-2, an interior column which supported the last bay of freshly placed concrete prior to the collapse.

**BSS147.** Center for Building Technology. *Performance criteria for solar heating and cooling systems in residential buildings. Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 147; 1982 September. 236 p. SN003-003-02418-0.*

**Key words:** building; cooling; heating; hot water; performance criteria; solar energy; standards.

This performance criteria, developed for the Department of Housing and Urban Development, is a baseline document for criteria and standards for the design, development, technical evaluation, and procurement of solar heating and cooling systems for residential buildings in accordance with the requirements of Section 8 of Public Law 93-409, the "Solar Heating and Cooling Demonstration Act of 1974." The document is intended to establish minimum levels of performance with regard to health and safety and the various aspects of technical performance. The criteria for health and safety put primary emphasis on compliance with existing codes and standards. The criteria on thermal and mechanical performance, durability/reliability and operation/servicing present performance requirements considered to be representative of acceptable levels. By the use of performance language in the document, it is believed that sufficient latitude has been provided to allow the innovation and flexibility that is essential for the stimulation of a viable solar industry at this time and in the future.



**BSS148.** Lew, H. S.; Fattal, S. G.; Shaver, J. R.; Reinhold, T. A.; Hunt, B. J. **Investigation of construction failure of reinforced concrete cooling tower at Willow Island, WV.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 148*; 1982 September. 156 p. SN003-003-02436-8.

Key words: collapse; concrete; concrete strength; construction; cooling tower; failure; hyperbolic shell; shell.

The collapse of the natural-draft hyperbolic concrete cooling tower unit no. 2 at the Pleasants Power Station at Willow Island, West Virginia, was investigated by the National Bureau of Standards. The investigation included on-site inspections, laboratory tests of construction assembly components and concrete specimens, and analytical studies.

Based on the results of these field, laboratory, and analytical investigations, it was concluded that the most probable cause of the collapse was due to the imposition of construction loads on the shell before the concrete of lift 28 had gained adequate strength to support these loads. The analysis of the shell indicated that the collapse initiated at the part of the shell in lift 28 where cathead no. 4 was located. It further showed that calculated stress resultants at several points in that part equaled or exceeded the strength of the shell in compression, bending, and shear. The failure of these points in that part of the shell would have propagated to cause the collapse of the entire lift 28.

**BSS149.** Salomone, L. A.; Kovacs, W. D.; Wechsler, H. **Thermal behavior of fine-grained soils.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 149*; 1982 November. 102 p. SN003-003-02463-5.

Key words: Atterberg Limit tests; compaction; compaction tests; heat flow; laboratory tests; soil moisture; soil tests; tests; thermal conductivity; thermal resistivity.

Laboratory thermal probe tests performed on an AASHTO standard reference material (a silty clay) showed that thermal resistivity ( $^{\circ}\text{C}\cdot\text{cm}/\text{watt}$ ) varies with soil moisture content and dry density. The tests were performed to correlate soil thermal behavior with the limit states of fine-grained soils. Over 80 thermal resistivity measurements were made on specimens compacted to various densities and moisture contents.

Results are presented which indicate that the optimum moisture content of soils and the Atterberg Limits can be correlated with the thermal behavior of fine-grained soils. It was found that the minimum thermal resistivity (i.e., the critical moisture content) occurred at the optimum moisture content when the soils were compacted using various compactive efforts. The critical moisture content defines the knee of the thermal resistivity versus moisture content curve. When the soils were compacted using a compactive effort of  $1.42 \times 10^5 \text{ J/m}^3$  (2970 ft-lbs per cubic foot), the minimum thermal resistivity occurred at the plastic limit of the AASHTO standard reference material. Also, indices are defined which allow comparison of the thermal behavior of fine-grained soils.



## 5.10 FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS

Publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations). This series is available only from the National Technical Information Service, Springfield, VA 22161.

**FIPS PUB 32-1.** Bag, T., Standards Coordinator. **Character sets for optical character recognition (OCR).** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 32-1*; 1982 June 25. 4 p.

Key words: character shapes; data entry; Federal Information Processing Standard; graphic shapes; magnetic ink characters; MICR; MICR Read Optically; OCR; optical character recognition.

This Federal Information Processing Standard supersedes FIPS PUB 32 and provides the description, scope, and identification of sets of graphic shapes to be used in applying Optical Character Recognition (OCR) in Federal Government agencies. American National Standards X3.2-1970 (R1976), X3.17-1981, and X3.49-1975 (R1982) are incorporated by reference. They supply all of the required dimensions, application rules, and reference sources.

A set of graphic shapes for special applications related to Magnetic Ink Character Reading (MICR) is provided and is designated MICR Characters Read Optically. This is a unique requirement for certain Federal Government agencies that has not yet been addressed by an American National Standard. Its principal function is to provide the different tolerances involved in optical character reading practice from certain requirements usually needed in magnetic ink reading practice.

**FIPS PUB 61-1.** Wong, M., Standards Coordinator. **Channel level power control interface.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 61-1*; 1982 July 13. 17 p.

Key words: automatic data processing (ADP); channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces.

This standard defines the functional, electrical, and mechanical interface specifications for a power control interface for use in connecting computer peripheral equipment as a part of automatic data processing (ADP) systems. This standard, together with a companion standard for I/O Channel Interface, defines the hardware characteristics for the I/O channel level interface. This revision supersedes FIPS PUB 61 in its entirety.

The Government's intent in employing this Channel Level Power Control Interface standard is to reduce the cost of satisfying the Government's data processing requirements through increasing its available alternative sources of supply for computer system components at the time of initial system acquisition, as well as in system replacement and augmentation and in system component replacement. This standard is also expected to lead to improved reutilization of system components.

When acquiring ADP systems and system components, Federal agencies shall cite this standard in specifying the power control interface for connecting computer peripheral equipment as a part of ADP systems.

**FIPS PUB 91.** Hogan, M., Standards Coordinator. **Magnetic tape cassettes for information interchange, dual track complementary return-to-bias (CRB) four-states recording on 3.81-mm (0.150-in) tape.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 91*; 1982 March 12. 4 p.

Key words: communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cassettes; magnetic tape recording; magnetic tape transports; standards.

This FIPS PUB announces the adoption of the American National Standard X3.59-1981, Magnetic Tape Cassettes for Information Interchange, Dual Track Complementary Return-to-Bias (CRB) Four-States Recording on 3.81-mm (0.150-in) Tape. This standard specifies the recorded characteristics for a magnetic tape cassette with data recorded on two tracks using complementary recordings and a return-to-bias method of encoding in order to provide for digital data interchange between information processing systems. This standard is one of a series of Federal Information Processing Standards implementing the Code for Information Interchange (FIPS 1-1) on flexible magnetic media.

**FIPS PUB 93.** Hogan, M., Standards Coordinator. **Parallel recorded magnetic tape cartridge for information interchange, 4-track, 6.30 mm (1/4 in), 63 bps (1600 bpi), phase encoded.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 93*; 1982 June 29. 2 p.

Key words: communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; standards.

This FIPS PUB announces the adoption of the American National Standard X3.72-1981, Parallel Recorded Magnetic Tape Cartridge for Information Interchange, 4 Track, 0.250 inch (6.30 mm), 1600 bpi, (63 bps), Phase Encoded. This standard specifies the recorded characteristics for a magnetic tape cartridge with data recorded across four parallel tracks at a recording density of 63 bits per millimeter (1600 bits per inch) using a phase encoding method of recording in order to provide for digital data interchange between information processing systems. This standard is one of a series of Federal Information Processing Standards implementing the Code for Information Interchange (FIPS 1-1) on flexible magnetic media.

## 5.11 VOLUNTARY PRODUCT STANDARDS

Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the Voluntary Product Standards program as a supplement to the activities of the private sector standardizing organizations.

No publications issued in this period.



Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other Government agencies.

**TN910-5.** Kostkowski, H. J.; Saunders, R. D.; Ward, J. F.; Popenoe, C. H.; Green, A. E. S. Self-study manual on optical radiation measurements: Part III—Applications, Chapter 1. Measurement of solar terrestrial spectral irradiance in the ozone cut-off region. *Natl. Bur. Stand. (U.S.) Tech. Note 910-5*; 1982 December. 91 p. SN003-003-02460-1.

Key words: atmospheric attenuation; atmospheric ozone; optical radiation measurements; radiometry; solar radiation; spectroradiometry; UV spectral measurements.

This is the first chapter in Part III (Applications) of this Manual. Material developed in earlier chapters is used to perform state-of-the-art measurements in Gainesville, Florida, of solar terrestrial spectral irradiance between 290 [nm] and 340 [nm]. The measurement equation is used to design the experiment and to address the effects of polarization, non-linearity, spectral scattering, distortion, slit-scattering function, spectral irradiance calibration, and wavelength calibration. Estimates are made of the uncertainties associated with all these factors. The total uncertainty is estimated to be about 10 percent. An appendix includes details for computing the solar terrestrial spectral irradiance between 280 and 310 [nm]. Suggestions are made for reducing the uncertainty by about one third and for further research in UV solar terrestrial measurements.

**TN1048.** Younglove, B. A. Interactive FORTRAN program to calculate thermophysical properties of six fluids. *Natl. Bur. Stand. (U.S.) Tech. Note 1048*; 1982 July. 56 p. SN003-003-02404-0.

Key words: argon; computer programs; density; enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume.

An interactive FORTRAN IV computer program is given for computing thermophysical properties of argon, ethylene, parahydrogen, nitrogen, nitrogen trifluoride, and oxygen. The program is designed for use with a computer terminal accessing a large computer in an interactive mode. The program provides prompting for selection of several options including: 1) choice of fluid, 2) choice of SI or engineering units, 3) choice of the single phase or liquid-vapor phase, and 4) a table of properties or a single value.

Properties are computed for the single phase region from input of two of the variables, temperature, pressure, and density. Values on the liquid-vapor boundary are computed from an entry of temperature or pressure. The program returns values for pressure, temperature, density, internal energy, enthalpy, entropy, specific heats at constant volume and pressure, and sound velocity. Viscosity, thermal conductivity, and dielectric constant are given for some of the fluids. Copies of the programs may be obtained from Office of Standard Reference Data, Attention: Reference Center, National Bureau of Standards, Washington, DC 20234.

**TN1049.** Zimmerman, J. E.; Sullivan, D. B. A study of design principles for refrigerators for low-power cryoelectronic devices. *Natl. Bur. Stand. (U.S.) Tech. Note 1049*; 1982 January. 114 p. Available from: NTIS; PB 82-215450.

Key words: cryocooler; cryogenics; low temperature; refrigerator; Stirling cycle; superconducting devices.

This report summarizes a five-year effort at NBS which has been directed toward the development of low-power cryocoolers suited to the support of superconducting instruments. The report deals with a variety of aspects of construction and operation of refrigerators as well as with a model which allows one to optimize the design for minimum drive power. The publications generated by the program are included as an appendix.

**TN1050.** Danielson, B. L. Backscatter signature simulations. *Natl. Bur. Stand. (U.S.) Tech. Note 1050*; 1981 December. 100 p. Available from: NTIS; PB 82-174186.

Key words: backscattering; backscatter signatures; optical fiber scattering; optical time-domain reflectometer; OTDR.

This report presents a collection of computer-generated backscatter signatures which represent realistic replicas of signals that can be encountered in optical time-domain reflectometer (OTDR) systems. Emphasis is placed on illustrating the appearance of backscatter signatures originating from localized and distributed imperfections which are superimposed on an otherwise uniform optical fiber. The details of these signatures are shown to be a function of the particular type of fiber perturbation, experimental parameters, and data reduction methods. This compilation of simulated responses is intended to facilitate the correct interpretation of OTDR signals as well as to point out sources of error which can arise in the characterization of optical fibers using backscatter techniques.

**TN1051.** Goodwin, R. D.; Haynes, W. M. Thermophysical properties of isobutane from 114 to 700 K at pressures to 70 MPa. *Natl. Bur. Stand. (U.S.) Tech. Note 1051*; 1982 January. 196 p. Available from: NTIS; PB 82-225988.

Key words: densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients.

Using a modified version of the nonanalytic equation of state, thermophysical properties of isobutane are derived from physical properties data and are tabulated at integral temperatures over the entire range of fluid states from 114 to 700 K along isobars at pressures to 70 MPa. Results include dielectric constants, densities, enthalpies, entropies, equation of state, internal energies, isobars, isochores, isotherms, Joule-Thomson inversion, heats of vaporization, melting line, orthobaric densities, specific heats, sound velocities, vapor pressures, and virial coefficients. In addition to the equation of state, equations are given for vapor pressures, orthobaric vapor and liquid densities, ideal gas properties, second virial coefficients, dielectric constants, heats of vaporization, melting pressures, and orthobaric liquid specific heats, enthalpies, and entropies. Several new sets of data have been used in this correlation; comparisons between experimental and calculated values are given.

**TN1052.** Sindt, C. F.; LaBrecque, J. F. An accuracy statement for a facility used to calibrate static pressure transducers and differential pressure transducers at high base pressure. *Natl. Bur. Stand. (U.S.) Tech. Note 1052*; 1982 June. 44 p. Available from: NTIS; PB 83-109652.

Key words: calibration; differential manometer; piston gage; pressure difference; pressure transducer; standards.

A facility has been developed to calibrate pressure transducers that are used in the NBS Gas Mass Flow Facility. Both static and differential pressure transducers can be calibrated. An air dead weight tester is the standard for static transducers in the range from 3.8 to 4.5 MPa. An air dead weight tester is also the standard for the differential pressure transducers in the range of 2.5 kPa to 50 MPa; a cistern manometer provides the transfer for the standard to a base operating pressure of 4.1 MPa. The calibration of the air dead weight gage adds  $\pm 69$  ppm to the calibration of the cistern manometer. This, plus the uncertainties in the high pressure corrections to the cistern manometer and our measurement of the mercury temperature, contributes  $\pm 690$  ppm to the uncertainty of the differential pressure transducer calibrations.

**TN1053.** Fickett, F. R. Electrical properties of materials and their measurement at low temperatures. *Natl. Bur. Stand. (U.S.) Tech. Note 1053*; 1982 March. 76 p. SN003-003-02390-6.

Key words: alloys; conductivity; electrical property; metals; polymers; resistance; resistivity; review.

A review is given of the electrical resistance of materials at cryogenic temperatures. Measurement techniques, the data base, and uses of the data are presented. The emphasis is on metals and alloys of technological importance; a topic which covers a large range of materials. Similarly, the treatment of theory and of measurement



techniques is primarily for the user interested in the more practical aspects of the subject. In every instance, however, references are given which allow the reader to pursue the subject at any level.

**TN1054.** Wilson, P. F.; Chang, D. C.; Ma, M. T. **Input impedance of a probe antenna exciting a TEM cell.** *Natl. Bur. Stand. (U.S.) Tech. Note 1054*; 1982 April. 52 p. Available from: NTIS; PB 82-234477.

**Key words:** Green's function; input impedance; probe antenna; radiation resistance; rectangular coaxial transmission line; TEM cell; variational method.

The input impedance of a probe antenna exciting a transverse electromagnetic (TEM) transmission line cell is formulated by a variational approach. The formulation also utilizes the results from a previous work on the field distribution inside a TEM cell excited by a vertical electrical Hertzian dipole. The final result of impedance is shown to consist of two distinct terms, which are respectively contributed by the ordinary rectangular waveguide and the gap perturbation. Numerical results for both the real and imaginary parts of the impedance are given. The resistive part is found to be proportional to the square of the probe length, and the reactive part largely capacitive.

**TN1055.** Siegwarth, J. D.; LaBrecque, J. F. **Tests of commercial densimeters for LNG service.** *Natl. Bur. Stand. (U.S.) Tech. Note 1055*; 1982 June. 40 p. Available from: NTIS; PB 83-115592.

**Key words:** densimeter; density; liquefied natural gas; methane.

Densimeters for liquefied natural gas (LNG) from four manufacturers were tested in liquid methane and an LNG-like mixture of methane, propane, and nitrogen in the density reference system (DRS). The calibration and performance of one type tested for the first time are reported. The stability of the calibrations and performances of three densimeters of a type previously tested have been examined and are also reported here.

**TN1057.** Johnson, E. G., Jr. **Beam-profile measurement of laser pulses using a spatial filter to sample the Hermite Modes for a string of pulses.** *Natl. Bur. Stand. (U.S.) Tech. Note 1057*; 1982 September. 44 p. SN003-003-02423-6.

**Key words:** computer simulation; laser beam profile; mode-matching analysis; spatial filter; target designators.

As a first step in the development of a beam-profile measuring instrument for laser sources that is capable of determining the distribution of low-order (less than 25) Hermitian modes in a series of laser pulses, I designed and evaluated the three key parts of such an instrument. First, there is the telescope system which allows the incident laser beam to be phase, beamwidth, and beam center matched to the optical spatial filter. Second, there is a brief error analysis of the structure of the mismatch function between the beam out of the telescope and that expected by the filter. Finally, there is the detailed analysis and design of the computer-generated spatial filter that will cause the incident-laser beam to be cross correlated with the low-order Hermite modes and will create an array of light spots in the detector (Fourier transform) plane each of which can be uniquely related to a particular Hermite mode of the original laser pulse.

The principal conclusion is that the Hermite mode analysis can be done with better than 99 percent separation between modes, provided the phase between modes is uncorrelated from pulse to pulse when the filter has been fabricated with a two-level, gray-scale structure which samples the profile with either 0 percent, or 100 percent transmission.

**TN1058.** Sanders, A. A.; Rasmussen, A. L. **A system for measuring energy and peak power of low-level 1.064  $\mu\text{m}$  laser pulses.** *Natl. Bur. Stand. (U.S.) Tech. Note 1058*; 1982 October. 44 p. SN003-003-02403-9.

**Key words:** APD transfer standards; beamsplitter attenuator; impulse response measurements; low-level laser measurements; modulated cw measurement system; PIN transfer standards; pulse energy; pulse peak power; 1.064  $\mu\text{m}$  laser pulse measurements.

For the first time, transfer standards have been developed for measuring 1.064  $\mu\text{m}$  laser pulses of duration about 10–100 ns, peak irradiance of about  $10^{-8}$ – $10^{-4}$  W/cm<sup>2</sup>, and fluences of about  $10^{-16}$ – $10^{-11}$

J/cm<sup>2</sup>. These energy and power measurement devices use PIN and APD silicon detectors, respectively, and can be used as stable transfer standards with total uncertainties (random errors computed at the 95 percent confidence level) of 10 to 15 percent. The system for calibrating these transfer standards is also described and consists of a cw Nd:YAG laser beam acousto-optically modulated to provide low-level laser pulses of known peak power and energy. A detailed evaluation of systematic and random errors is also shown.

**TN1059.** Ma, M. T.; Koepke, G. H. **A method to quantify the radiation characteristics of an unknown interference source.** *Natl. Bur. Stand. (U.S.) Tech. Note 1059*; 1982 October. 60 p. SN003-003-02441-4.

**Key words:** dipole moments; electrically small; interference source; leakage; phase measurements; power measurements; radiation pattern; TEM cell; total radiated power.

A new method for determining the radiation characteristics of leakage from electronic equipment for interference studies is described in this report. Basically, an unintentional leakage source is considered to be electrically small, and may be characterized by three equivalent orthogonal electric dipole moments and three equivalent orthogonal magnetic dipole moments. When an unknown source object is placed at the center of a transverse electromagnetic (TEM) cell, its radiated energy couples into the fundamental transmission mode and propagates toward the two output ports of the TEM cell. With a hybrid junction inserted into a loop connecting the cell output ports, one is able to measure the sum and difference powers and the relative phase between the sum and difference outputs. Systematic measurements of these powers and phases at six different source object positions, based on a well-developed theory, are sufficient to determine the amplitudes and phases of the unknown component dipole moments, from which the detailed free-space radiation pattern of the unknown source and the total radiated power can be determined. Results of simulated theoretical examples and an experiment using a spherical dipole radiator are given to illustrate the theory and measurement procedure.

**TN1150.** Pommersheim, J. M.; Campbell, P. G.; McKnight, M. E. **Mathematical models for the corrosion protective performance of organic coatings.** *Natl. Bur. Stand. (U.S.) Tech. Note 1150*; 1982 September. 99 p. SN003-003-02417-1.

**Key words:** absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water.

Mathematical models were developed for conceptual models describing the principal phenomena that occur in the corrosion performance of polymeric coatings. These include models for water and oxygen permeability through organic coatings, models for the growth of blisters beneath coatings, and preliminary models for the polarization occurring at the electrode surfaces. Results predicted by the models are discussed in terms of the improvement of the protective function of the membrane.

**TN1151.** Vorburger, T. V.; Scire, F. E.; Teague, E. C. **Surface roughness measurements of circular disks and their correlation with hydrodynamic drag.** *Natl. Bur. Stand. (U.S.) Tech. Note 1151*; 1982 January. 63 p. Available from: NTIS; PB 82-156985.

**Key words:** disks; drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus; surface roughness; surface topography.

The problem of relating hull roughness to the drag of ships is a complex and important one in ship research. One of the complications is that there are three fairly distinct roughness regimes (microroughness, macroroughness, and structural roughness) which make up a ship's surface and their relative importance is not yet well understood. The present report focuses on stylus measurements of the microroughness of rotating disks and their significant correlation with drag measurements. In particular, the roughest disks had drag coefficients  $C_m$  that were  $\sim 30$  percent greater than those of the smoothest disks. The following empirical formula was derived to relate  $C_m$  with the roughness average  $R_a$  and the peak-count wavelength  $\lambda_{pc}$  at a Reynold's number of  $1.5 \times 10^6$ .  $C_m = bR_a/(\lambda_{pc})^{1/2} + C_0$ , where  $b = 3.85 \pm 0.22 \times 10^{-3} \mu\text{m}^{-1/2}$  and  $C_0 = 6.48 \pm 0.07 \times 10^{-3}$ . The formula was observed to hold for both painted and bare metal disks.



**TN1153.** Kratochvil, B. G.; Taylor, J. K. A survey of the recent literature on sampling for chemical analysis. *Natl. Bur. Stand. (U.S.) Tech. Note 1153*; 1982 January. 27 p. Available from: NTIS; PB 82-166265.

Key words: chemical analysis; sampling; sampling atmospheres; sampling food; sampling miscellaneous materials; sampling plan; sampling water.

Sampling is one of the most important steps in chemical analysis, yet it is often poorly planned and executed. One reason is that key information on sampling is scattered and relatively inaccessible. This article summarizes the more important published articles obtained as the result of a literature search to obtain essential background information for the design of sampling plans and protocols for the National Environmental Specimen Bank. Each reference is briefly described so that its applicability to a specific sampling question can be judged. The compilation consists of 56 references on general aspects of sampling, 9 references on sampling agricultural and food products, 14 references on sampling atmospheres and gases, 18 references on sampling water and waste water, and 18 references on sampling miscellaneous materials.

**TN1154.** Gramlich, J. W.; Shideler, R. W. A programmable sample dryer for thermal ionization mass spectrometry. *Natl. Bur. Stand. (U.S.) Tech. Note 1154*; 1982 January. 19 p. Available from: NTIS; PB 82-158783.

Key words: isotopic analysis; isotopic fractionation; sample dryer; thermal ionization mass spectrometry.

A sample dryer has been designed which allows reproducible and automatic filament current and timing adjustments for up to five separate steps. Designed around inexpensive TTL logic, the dryer may be programmed by resistors on a plug-in card to provide the proper drying conditions, be programmed to stop and signal the operator after any step, or be allowed to continue uninterrupted through the entire drying sequence. A programmable 110 volt output is provided for controlling a heat lamp or other accessory.

**TN1155.** Hillhouse, D. L.; Petersons, O.; Sze, W. C. A simplified system for calibration of CCVTs in the substation. *Natl. Bur. Stand. (U.S.) Tech. Note 1155*; 1982 May. 57 p. Available from: NTIS; PB 82-215419.

Key words: CCVTs; EHV revenue metering; energy metering; field calibration; metering accuracy CCVTs; 500 kV; 500 kV substation measurements.

Coupling capacitor voltage transformers (CCVTs) are widely used for the revenue metering of energy exchanged between utilities at EHV (345–500 kV) interties. These devices are installed permanently in substations, and must be calibrated there. Allowable error is  $\pm 0.3$  percent and  $\pm 4.6$  mrad (milliradians).

NBS developed, and has had in operation for several years, a prototype system for field calibration of these CCVTs. This prototype system is more accurate, more complicated, more bulky, and more costly than is essential for this application.

This report describes a simplified, lighter, and less costly CCVT calibration system, newly developed and field tested by NBS. The principal elements of this system are a portable reference standard transformer and moderate voltage power supply (14.4 kV), a modular capacitive transfer standard divider, and a voltage comparator. Results obtained with this system agree with the prototype to within  $\pm 0.03$  percent and  $\pm 0.1$  mrad.

The prototype system is installed permanently in a dedicated calibration truck. The new system could operate with a non-dedicated truck to transport the disassembled modular divider, and a van to transport the rest of the components and to serve as a field laboratory.

**TN1156.** Clark, R. E. The CSA weatherization demonstration data base: Contents and descriptions. *Natl. Bur. Stand. (U.S.) Tech. Note 1156*; 1982 February. 159 p. SN003-003-02385-0.

Key words: Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration;

residential energy consumption; space heating consumption; weatherization.

The Community Services Administration (CSA) National Optimal Weatherization Demonstration was conducted over a 3 1/2 year period (1977–1981) by the National Bureau of Standards and Community Action agencies in 12 areas around the Nation, principally to determine what reductions in residence space heating energy consumption could be achieved by extensive, economically cost-effective weatherization of dwellings. Because the project was funded by the CSA, it was conducted using houses occupied by low-income households. In addition to recording overall energy consumption (for the 1975–1980 period), the demonstration collected considerable additional energy-related measurements from approximately 240 houses (including some 40 unweatherized control houses) at the 12 sites. These measurements probably constitute the most extensive and comprehensive data base on real energy usage of real houses extant. The report describes the various measurements that were obtained and how they were obtained. It contains house-by-house inventories of the data actually present in the data base and, as an access aid for further study of the data, it describes the media in which the data exist.

**TN1157.** Marx, E. Integral equations for transient electromagnetic fields. *Natl. Bur. Stand. (U.S.) Tech. Note 1157*; 1982 February. 68 p. Available from: NTIS; PB 82-178096.

Key words: dyadic Green functions; electromagnetic scattering; integral equations; perfect conductors; transient electromagnetic fields; wave equations.

Integral equations for the electric and magnetic fields in free space are derived from Maxwell's equations. The fields are expressed in terms of their initial values, boundary values, and sources with the help of a retarded Green function for the scalar wave equation. These equations are then used to derive integral equations for the surface charge and current densities induced by the scattering of a transient electromagnetic field by perfect conductors. An alternative solution of Maxwell's equations with the help of dyadic Green functions is also presented.

**TN1158.** Jones, F. E.; Houser, J. F.; Schoonover, R. M. Accountability tank volume calibration data. *Natl. Bur. Stand. (U.S.) Tech. Note 1158*; 1982 August. 12 p. SN003-003-02407-4.

Key words: accountability tank; calibration; differential pressure; volume; volumetric test measures; water calibration.

This paper presents the very precise data from the volume calibration of a nuclear materials input accountability tank and briefly describes the treatment of the data. The calibration system involves the use of volumetric test measures for dispensing known increments of the calibration fluid (water) into the tank, and a null-operated quartz bourdon-type differential pressure gage for measuring the differential pressure between the bottom of the bubble on the tip of a "bubbler" tube near the bottom of the tank and a port in the top of the tank. The tank is essentially a right circular cylinder with a capacity of approximately 13,600 L (3,600 gal). The height is approximately 3.4 m (11 ft) and the diameter is approximately 2.4 m (8 ft). The water volume and the differential pressure were adjusted to correspond to the reference temperature, 25.00°C.

**TN1159.** Bell, B. A.; Field, B. F.; Kibalo, T. H. A fast response, low-frequency sampling voltmeter. *Natl. Bur. Stand. (U.S.) Tech. Note 1159*; 1982 August. 113 p. SN003-003-02408-3.

Key words: algorithm; converter; distortion; microcomputer; rms value; sampling; signal period.

A low-frequency voltmeter utilizing a sampling technique implemented with microprocessor-based electronics has been developed to perform as a true rms ac voltmeter and distortion analyzer. The instrument makes measurements accurate to  $\pm 0.1$  percent (of reading) of the fundamental frequency, total harmonic distortion, and true rms voltage of approximately sinusoidal inputs from 2 mV to 10 V and frequencies from 0.1 to 120 Hz. A major feature of this instrument is the special window crossing and error function algorithms which provide a software means for completing a measurement within two signal periods at frequencies below 10 Hz.



**TN1160.** Shorten, F. J., ed. **NBS reactor: Summary of activities July 1980 through June 1981.** *Natl. Bur. Stand. (U.S.) Tech. Note 1160*; 1982 June. 204 p. Available from: NTIS; PB 82-240698.

**Key words:** activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation.

This report summarizes all those programs which depend on the NBS reactor. It covers the period from July 1980 through June 1981. The programs range from the use of neutron beams to study the structure and dynamics of materials through nuclear physics and neutron standards to sample irradiations for activation analysis, isotope production, radiation effects studies, neutron radiography, and nondestructive evaluation.

**TN1161.** Levy, C. R. **Testing to quantify the effects of handling of gas dielectric standard capacitors.** *Natl. Bur. Stand. (U.S.) Tech. Note 1161*; 1982 October. 44 p. SN003-003-02452-0.

**Key words:** calibration; measurement assurance; reference standards; standard capacitors; standard qualification.

A test method known as the "Handling and Stability Test" is currently being used at NBS as part of the requirement for the five-part-per-million calibration of gas-dielectric standard capacitors. This test is used to achieve qualitative information on the effects of mechanical shock from shipping and handling on standard capacitors and to rank them quantitatively with respect to these effects.

**TN1162.** Free, G.; Morrow, J. **Transportable 1000 pF standard for the NBS capacitance measurement assurance program.** *Natl. Bur. Stand. (U.S.) Tech. Note 1162*; 1982 October. 9 p. SN003-003-02444-9.

**Key words:** calibration; measurement assurance; measurement assurance programs; reference standards; standard capacitors; standard qualification; transfer standards.

A capacitance transport standard has been constructed for use in the National Bureau of Standards Measurement Assurance Program. The transport standard was designed so that variations in ambient temperature and mechanical shock would have a minimal effect on the value of the internal reference capacitors. A significant improvement in stability of 1000 pF capacitors during shipment and in the laboratory has been achieved through this design.

**TN1163.** Bremer, S. G.; Peavy, S. T. **A systems programmer's guide for installing OMNITAB 80.** *Natl. Bur. Stand. (U.S.) Tech. Note 1163*; 1982 August. 72 p. SN003-003-02415-5.

**Key words:** ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; system parameters; transportable computer software.

OMNITAB 80 is a general-purpose package which permits direct use of a computer without prior knowledge of computer languages. Every effort has been made to produce a system as computer independent as possible to make installation on any large computer configuration relatively easy.

This Technical Note provides assistance to the systems programmer, with the task of installing OMNITAB 80, by pointing out where difficulties may occur and how to resolve them. The Note is intended more as reference material, since all modifications for a particular configuration are made prior to the distribution of the OMNITAB 80 system.

OMNITAB 80 is a large system requiring a large computer. Overlay or segmentation is virtually essential. A method, that is employed at the National Bureau of Standards, for overlaying OMNITAB 80 is outlined. The method should be useful for other computer configurations.

**TN1164.** Croarkin, C.; Varner, R. N. **Measurement assurance for dimensional measurements on integrated-circuit photomasks.** *Natl. Bur. Stand. (U.S.) Tech. Note 1164*; 1982 August. 50 p. SN003-003-02420-1.

**Key words:** IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; tests for

systematic error; uncertainty.

Optical Microscope Linewidth-Measurement Standards, SRM-474 and SRM-475, have been developed by NBS for optical imaging systems capable of making line-spacing and linewidth measurements in the 0.5  $\mu\text{m}$ -12  $\mu\text{m}$  regime on IC photomasks. Each artifact affords a means of reducing systematic errors via a calibration curve and keeping the optical system in statistical control. Procedures are given for accomplishing these goals along with a discussion of the uncertainty of the calibrated values.

**TN1166.** Williams, E. S. **The practical uses of ac-dc transfer instruments.** *Natl. Bur. Stand. (U.S.) Tech. Note 1166*; 1982 October. 37 p. SN003-003-02445-7.

**Key words:** ac current measurements; ac voltage measurements; ac-dc comparator; ac-dc difference; thermoelement.

Alternating currents and voltages are measured most accurately at this time when they are compared with nominally equal and known dc currents and voltages. The comparisons are usually made with thermal transfer instruments which respond nearly equally to ac and dc quantities. Practical information and recommended procedures are given for using these instruments along with diagrams of apparatus and examples of typical data and calculations. Methods for minimizing difficulties caused by dc reversal differences, thermal drift, energy picked up from local electromagnetic fields, and the deviation from square-law response of these instruments are considered. Causes of ac-dc differences are discussed, and methods for measuring them and applying corrections are also described.

**TN1167.** Calabrese, J. T.; Kaetzel, L. J.; Glass, R. A.; Smith, G. R. **A computer data base system for indexing research papers.** *Natl. Bur. Stand. (U.S.) Tech. Note 1167*; 1982 October. 102 p. SN003-003-02432-5.

**Key words:** computer indexing; data base; directory look-up; information retrieval; interactive processing; random access.

This report represents a significant revision to NBS Technical Note 1123 published in 1980. In that report, the Kaetzel, Glass, Smith (KGS) data base system permitted users to index, edit, classify, and retrieve scientific research paper citations. During the past 15 months, the system was modified and enhanced. All programs are written in standard FORTRAN VII Level I programming language providing transportability among computer systems. Retrieval time has been greatly reduced by changing from a sequential access method to an indexed, directory look-up file structure which allows faster and more efficient random access. The file structure is machine independent. Because of the responsiveness of the extract mode, the one-key retrieval is unnecessary and has been deleted from the revised system. The keyword mode has been replaced by the information mode which provides statistics on authors and keywords. A file maintenance mode has been added to ensure data base integrity. The KGS system has been separated from the larger Publications Data Base and the select data base mode has been removed. Software has been tailored to meet KGS users' needs. Overall, the revised system is faster and uses resources more efficiently than the original data base.

**TN1168.** Varner, R. N. **Computer software for measurement assurance of gage blocks.** *Natl. Bur. Stand. (U.S.) Tech. Note 1168*; 1982 October. 58 p. SN003-003-02426-1.

**Key words:** computer software; FORTRAN; gage blocks; measurement assurance; statistical control; statistical tests.

This document is intended for those who are interested in computer software needed to provide, on a continual basis, a measurement assurance procedure for calibrating gage blocks where a test set of gage blocks is measured against two standard sets with control being on the difference of the two standards. A thorough discussion is given of the software including its implementation and usage. A hard copy or a magnetic tape of the software is available on request.

**TN1169.** Cohen, J. **Introduction to noise in solid state devices.** *Natl. Bur. Stand. (U.S.) Tech. Note 1169*; 1982 December. 63 p. SN003-003-02457-1.

**Key words:** electronics; noise; photon detector; rectifier; solid state devices; transistor.



This is a short didactic monograph on electronic noise which aims to impart a "feel for the subject." The work is divided into two parts. The first, Theory, deals in detail with the principal noises found in solid state devices, namely shot noise, thermal noise,  $1/f$  noise, and generation-recombination noise. The second part, Applications, is a systematic treatment of noise in selected solid state devices. Analyses progress from a single noise source in a circuit element to four noises in a device; concomitantly equivalent circuits are developed to facilitate the solution of various complex noise problems. Examples treated in this part include resistors, rectifiers, transistors, and photo-detectors. The work concludes with a recapitulation and useful references.

**TN1170.** Clark, E. J.; Roberts, W. E. **Weathering performance of cover materials for flat plate solar collectors.** *Natl. Bur. Stand. (U.S.) Tech. Note 1170*; 1982 November. 80 p. SN003-003-02454-6.

Key words: artificial weathering; cover plate materials; durability; natural weathering; solar collectors; solar energy; solar energy transmittance; tensile properties; weathering of cover plates.

Weathering studies were performed to obtain data on the performance and durability of cover plate materials for flat plate solar collectors used in solar heating and cooling systems. Ten materials were evaluated to assess their durability after natural weathering and artificial weathering with a xenon arc light. The materials were weathered for four years on small minicollectors in Arizona, Florida, and Maryland after which the solar energy transmittance and the effect of dirt on the transmittance were measured. The tensile properties of selected film materials were also assessed after weathering. The effects of the natural weathering are compared: (1) for materials exposed as inner and outer cover plates for each weathering site; (2) for the three weathering sites; and (3) with materials artificially weathered with a xenon arc light.

**TN1171.** Lieberman, A. G. **An electromagnetic formulation for treating optical reflections from graded-material surfaces.** *Natl. Bur. Stand. (U.S.) Tech. Note 1171*; 1982 December. 36 p. SN003-003-02467-8.

Key words: electromagnetic waves; graded materials; inhomogeneous media; jellium; optical reflections; reflection coefficient; Ricatti equation; surface reflections; wave impedance.

The reflection of a monochromatic plane wave falling obliquely upon the surface of an arbitrary, flat, depth-dependent material is investigated theoretically. The complex reflection coefficient for either principal (s or p) polarization of the field is shown to satisfy a non-linear differential equation of the Ricatti type. An alternate formulation based on the wave impedance (i.e., impedance or admittance) functions is also presented. The impedance functions are shown to satisfy Ricatti differential equations of their own. The reflection coefficient formulation and the wave impedance formulations are related via a bilinear algebraic transformation. Singularities appearing in the reflection coefficient formulation may be suppressed in the impedance formulation, and vice-versa. The advantage of either formulation is that the reflection coefficients for an arbitrary, depth-dependent medium can be obtained directly without having to solve Maxwell's equations for the internal field configurations.

### 5.13 CONSUMER INFORMATION SERIES

Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

No publications issued in this series during this period.



## 5.14 NBS INTERAGENCY REPORTS

A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution by the National Technical Information Service (NTIS), Springfield, VA 22161, in paper copy or microfiche form unless otherwise stated. When ordering this series from NTIS you must order it by the "COM, PB, or AD" number listed at the end of each entry.

**NBSIR 80-2046.** Flaherty, K. Innovation in State public utility commissions: An exploratory study of techniques in energy regulation. 1980 June. 368 p. Available from: NTIS; PB 83-134494.

Key words: computerized analysis; electric utility rate regulation; Experimental Technology Incentives Program; innovation; productivity analysis.

The research described in this study explores the implementation issue of four techniques in electric utility rate regulation by state public utility commissions. The techniques, considered innovations not previously used by a given state public utility commission, were advanced by the Experimental Technology Incentives Program in a project which explored regulatory lag and other hypotheses about the effect of regulatory improvements on technology. Two particular objectives were pursued: 1) To explore and describe the diffusion and adoption of computerized analysis, productivity analysis, time-of-day pricing and future test periods for rate making purposes in the state commissions; and 2) To apply and evaluate the "innovation-decision" research design proposed by Downs and Mohr (1976).

**NBSIR 80-2119.** Elder, J., (NBS contact: L. Beavers). State-of-the-art summary of incentives for residential water conservation. 1981 October. 37 p. Available from: NTIS; PB 81-115958.

Key words: consumer education; energy conservation; feedback; incentives; metering; rate structures; water conservation.

Water conservation programs are being discussed and implemented throughout the country. It appears, however, that unless there is a water crisis, these programs have little effect on domestic consumption. Why have water conservation programs been ineffective? What incentives exist for the individual homeowner to conserve water? This report addresses some programs and techniques that have been developed to encourage residential water conservation. Energy conservation techniques that appear to be directly relevant to water conservation have also been included. Specific areas covered are: consumer education and information programs, feedback techniques, possible incentives in mass-metered residences, and the impact of pricing on water consumption. An extensive bibliography is included.

**NBSIR 80-2120.** Fang, J. B.; Breese, J. N., (NBS contact: N. Jason). Fire development in residential basement rooms. 1981 October. 97 p. Available from: NTIS; PB 81-141509.

Key words: building fires; fire resistance; fire tests; flow measurement; gas temperatures; heat release rate; interior finishes; residential buildings; room fires.

A multi-phase study program has been established to develop a rational test procedure for evaluating the fire resistance of residential floor assemblies. The first phase of this research program was aimed at characterizing the severity of fires originating in residential rooms and developing a specified set of fire exposure conditions applicable for fire resistance testing of floor constructions.

A total of 16 burnout tests were conducted to investigate the fire behavior in typical residential recreation rooms of single family houses. These fire tests were usually run for one hour and were performed in two instrumented test rooms, 3.3×3.3×2.4 m and 3.3×4.9×2.4 m in width, length, and height respectively, furnished with household furniture and lined with interior finish materials typical of actual occupancies. Measurements were made of the temperature, heat flux, static pressure, smoke density, gas velocity, species concentration, and oxygen consumption. The effects of such parameters as the ventilation, fire load density, initial item ignited, room size, and thermal and flammable properties of the wall and ceiling materials on the fire severity were evaluated quantitatively. A fire exposure temperature-time curve which is different from the ASTM E 119 curve, has been developed for testing the fire resistance

of such building structures.

**NBSIR 80-2176.** Levy, J.; Petersen, S. R. Economic efficiency in the sizing of residential heat pumps. 1981 July. 80 p. Available from: NTIS; PB 82-179029.

Key words: benefit-cost analysis; energy conservation; equipment selection; equipment sizing; heat pump; life-cycle costs.

This report provides a methodology for determining the optimal heat pump size, in terms of heating output capacity, for residential installations having annual heating requirements significantly greater than annual cooling requirements. The optimal size heat pump is defined as the size for which total present value, life-cycle heating and cooling costs (including equipment costs) are minimized. Incremental energy savings from increasing the output capacity of the heat pump are calculated using hourly simulation models of heat pump and building performance developed at NBS. The dollar value of the incremental savings, in present-value, life-cycle terms, is then calculated and compared with incremental costs to determine the optimal heat pump size. A base case analysis of an 1800 square-foot house in the Chicago climate shows that a slightly larger heat pump size than would typically be selected for air conditioning purposes alone is optimal for the assumptions specified. A number of sensitivity analyses are performed to show the effects of changes in load size, degradation coefficients, power utilization efficiency, economic assumptions and geographic location on the optimal heat pump size.

**NBSIR 81-1652.** Larson, D. R. A measurement method for determining the optical and electro-optical properties of a thin film. 1981 December. 64 p. Available from: NTIS; PB 82-177981.

Key words: electro-optic modulation; hydrogenated amorphous silicon; optical transmittance; refractive index; scattering matrix; thin film; transmittance extrema.

A method of determining the complex refractive index of a thin film on a nonabsorbing substrate is developed. The optical transmittance spectrum of the structure is measured and the index is determined by matching this spectrum numerically. An iterative procedure for finding the magnitude of an induced change in refractive index is also presented. In nonabsorbing spectral regions, the index and film thickness are determined directly.

The optical transmittance of sapphire and thin films of gold and epitaxial silicon, both on sapphire, is examined. The refractive index of epitaxial silicon on sapphire, SOS, is determined and compares favorably with the results of other investigators.

The measurement method is applied to a thin film of hydrogenated amorphous silicon, a-Si:H, deposited by a capacitively coupled rf glow discharge. The index is tabulated for various wavelengths and a field induced change in index comparable to GaAs is measured.

**NBSIR 81-1655.** Siegwarth, J. D.; LaBrecque, J. F. Estimated uncertainty of calibrations of freestanding prismatic liquefied natural gas cargo tanks. 1982 January. 281 p. Available from: NTIS; PB 82-188186.

Key words: calibration accuracy; laser calibration; LNG ship tanks; photogrammetry; volume calibration.

The accuracy of the tank calibrated by the photogrammetric technique was examined during the calibration of fifteen freestanding prismatic LNG transport tanks. This examination indicated that the calibration accuracy of the tanks calibrated in the storage position was better than ±0.1%. Additional factors influencing the accuracy of the calibration of the tanks, such as the effects of installing the tanks into the ship and loading the ships with LNG, were examined in the course of this work and the results are reported here. The various measurements used by various NBS personnel to analyze the calibration accuracy are detailed in the eight Appendices included in this report.

**NBSIR 81-1656.** Counas, G. J.; Bremer, T. H. NBS 30/60 megahertz noise measurement system operation and service manual. 1981 December. 180 p. Available from: NTIS; PB 82-178989.

Key words: automated noise measurement system; coaxial noise sources; controller; IEEE 488 Bus; total power radiometer.

Calibration of coaxial noise sources at 30 and 60 MHz is now being



accomplished using a total power radiometer designed to operate under computer control. Use of the IEEE 488 Instrument Bus and structured software techniques allows use and substitution of commercially available components with a minimum of hardware and software modification.

This manual addresses the general theory of operation, operating procedures, and maintenance procedures for the NBS 30/60 MHz automated noise measurement system using a commercially available desktop calculator as the controller.

**NBSIR 81-1657.** Smith, D. R.; Hust, J. G.; Van Poolen, L. J. A guarded-hot-plate apparatus for measuring effective thermal conductivity of insulations between 80 K and 360 K. 1982 January. 56 p. Available from: NTIS; PB 82-169121.

Key words: guarded-hot-plate apparatus; insulation; low-temperature; thermal conductivity.

This report describes a guarded-hot-plate apparatus used to determine the effective thermal conductivity of glass fiber insulations. Measurements can be performed at temperatures from 80 K to 360 K, from atmospheric pressure to a vacuum of  $10^{-4}$  Pa ( $1 \times 10^{-6}$  torr). Various fill gases such as air, nitrogen, argon, and helium can be utilized. Overall uncertainties of thermal conductivities at atmospheric pressure are 1% at the higher temperatures and 5% at the lower cryogenic temperatures. The modifications of the commercial apparatus described in this report resulted in approximately a four-fold improvement in uncertainty.

**NBSIR 81-2233.** Stroik, J. S. High security locking devices. A state-of-the-art report. 1981 January. 175 p. Available from: NTIS; PB 82-165499.

Key words: characteristics; door security; entry control; hardware; installation; locking device classification; lock operation.

An investigation was made of the literature and information related to high security, internal locking devices. The purpose of this work was to identify and document the present state-of-the-art of these devices and systems used on doors. This document supports an R & D effort to develop a locking system for sensitive ordnance structure doorways that will take the place of existing surface mounted padlocks and hasps. Locking systems were investigated both overall and their subsystem components, including bolt-works, bolt-work driving subsystems, locking mechanisms and the protective envelope. Usual categories of lock types are presented, and a new combined summary of locking device classifications is suggested to act as a standard basis for future research and development of standards. This classification divides locks by their operation, installation and component characteristics. A review of the literature includes an annotated bibliography, annotated lists of standards and specifications, national organizations and locksmith schools, a selected list of manufacturers and a glossary compiled from available glossaries. An appendix includes selected samples of manufacturers' catalogue information. As a result of this investigation, the author provides specific recommendations concerning the needs of more technical study and research together with suggested development and implementation of standard test methods.

**NBSIR 81-2285.** Hurley, C. W.; Kopetka, P. A.; Kelly, G. E. Using microcomputers to monitor the field performance of residential heat pumps. 1981 June. 118 p. Available from: NTIS; PB 81-240608.

Key words: analog signal conditioning; data acquisition system; field data acquisition; field instrumentation; field performance of heat pumps; heat pumps; heat pump test methods; microcomputer.

Field data on the heating and cooling performance of residential heat pumps were gathered for the purpose of verifying and refining laboratory testing procedures. This report describes the procedures, instrumentation, and microprocessor-based data acquisition system (DAS) used for evaluating the field performance of three residential heat pumps located in the Washington, D.C. area. The instrumentation, signal conditioning unit and DAS are described in detail since the designs employed are applicable to future testing projects of this type in both small and large scale field studies.

To avoid the large capacities of the DAS and data reduction facility required for on-line monitoring, a strategy was developed

which used the on-line microcomputer in the field to reduce and analyze the raw data and record the calculated results. This reduced the amount of recorded data to an acceptable level and thereby extended the time period between data collection.

This report discusses the selection of the heat pumps utilized in this field study and the design and selection of the instrumentation and DAS. The requirements for scanning data and recording the results are also discussed.

The basic equations and the software for processing the data at the field units and for reducing and editing the raw data disks at a central microcomputer are described. Examples of printouts taken directly at the field units and from the data disks are shown.

**NBSIR 81-2287.** Mulroy, W. J.; Kelly, G. E. Laboratory tests of a residential unitary water-source heat pump. 1982 November. 51 p. Available from: NTIS; PB 83-137141.

Key words: central heating equipment; cooling; heating; heating seasonal performance; heating seasonal performance factor; heat pumps; test method; water source heat pumps.

The performance of a residential heat pump was measured in the laboratory over a broad range of source water temperatures (40°F to 90°F). Tests were performed in both heating and cooling operational modes and for both steady-state and cyclic operation.

For both heating and cooling operations, the unit capacity and COP were found to be linear functions of the average of the unit source and outlet water temperatures. In heating, the unit capacity, COP, and part load performance increased with increasing water temperature. In cooling, the unit capacity, COP, and part load performance decreased with increasing water temperature. The measured degradation coefficients ranged from 0.09 to 0.21 for heating and from 0.10 to 0.18 for cooling. An appendix is included in which the effect of the degradation coefficient and of supplemental resistance heat on the unit heating and cooling seasonal performance factors is calculated.

**NBSIR 81-2314.** Smith, L. E.; Chang, S. S.; Senich, G. A. Migration of low molecular weight additives in polymers. 1981 September. 41 p. Available from: NTIS; PB 83-117267.

Key words: additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC.

Migration of three additives, n-octadecane, n-dotriacontane, and butylated hydroxytoluene (BHT), from linear (LPE) and branched polyethylene (BPE) into several oil-simulating solvents is studied at 30 to 60°C. Diffusion coefficients of the three migrants from BPE into n-octanol are about the same as those into ethanol. The diffusivity of BHT migrating from LPE into n-octanol is two to four times greater than that for ethanol extraction. Diffusion coefficients of the migrants from BPE into the synthetic triglyceride HB307 are about equal to those in ethanol and other triglycerides. Diffusivities for 95% ethanol extractions of BPE are reduced by a factor of two thirds to one half from the corresponding anhydrous ethanol values. The quantity of migrant extractable by 95% ethanol is more strongly governed by the change in partition coefficient, however. For BHT migrating from an (ethylene-5% vinyl acetate) copolymer diffusivities are only slightly higher for n-heptane but about three times greater in ethanol and corn oil extractions compared to those for BPE. A literature survey on the migration of organotin compounds, particularly di-n-octyltin stabilizers, from poly(vinyl chloride) into foods and food-simulants is also given.

**NBSIR 81-2339.** Brown, P. W.; Grimes, J. W., Jr. Simulated service testing for corrosion in solar heating and cooling systems. 1981 September. 34 p. Available from: NTIS; PB 82-179037.

Key words: corrosion; elevated temperature; heat transfer liquid degradation kinetics; simulated service test solar collector.

This study was undertaken to evaluate a proposed ASTM simulated service test methodology to evaluate corrosion or heat transfer liquid degradation. The responses of aluminum, copper, and stainless steel to conditions simulating flow and stagnation in solar collector systems were evaluated. The chemical stabilities of ethylene and propylene glycol solutions at elevated temperature were also examined.



**NBSIR 81-2340.** Smith, B. M.; Sheridan, T. B.; Albus, J. S.; Barbera, A. J.; VanderBrug, G. J. *A glossary of terms for robotics*. 1981 October. 88 p. Available from: NTIS; PB 82-251216.

**Key words:** automation; computer aided manufacturing; glossary; materials handling; robotics; robots.

The use of emerging robotics technology along with that of numerical control of machining processes offers enormous promise for improving productivity in discrete part batch manufacturing operations. This glossary of terms has been assembled in order that users, vendors, researchers, students, teachers, and others involved with the rapidly developing field of robotics may communicate in terms which are shared and understood in common. There is no claim that the definitions provided are in any sense standards accepted by any official body. This document does in fact represent only an initial draft, and it is expected and encouraged that informed reviewers will comment, revise, add or delete terms to make this glossary a useful reference tool.

**NBSIR 81-2344.** Walton, W. D.; Waksman, D. *Fire testing of roof-mounted solar collectors by ASTM E 108*. 1981 August. 75 p. Available from: NTIS; PB 82-117698.

**Key words:** fire tests; roofing fire resistance; roofing fire tests; solar collectors.

A study was undertaken to investigate the use of ASTM E 108 (NFPA 256, UL 790), Fire Tests of Roof Coverings, for testing roof-mounted solar energy collectors. The ASTM E 108 test method is commonly referenced in building codes as the procedure for determining the fire characteristics of roof coverings. To date, no data have been available regarding the influence of solar collectors on the fire characteristics of roof coverings or on collectors used as roof coverings. This study focused primarily on class C intermittent flame, spread of flame, and burning brand tests, although several class A and B burning brand tests were conducted. The collectors studied were commercially available and constructed with a broad variety of glazing, casing, and insulation materials representative of those commonly in use. The collectors were tested on sloped, asphalt shingled roofs with three types of mountings: integrally as the roof, directly on the roof covering, and on standoffs above the roof covering. Data are presented showing the results of the testing conducted. An evaluation of the testing procedures as they apply to roof-mounted solar collectors is given.

**NBSIR 81-2345.** Parker, V. B.; Staples, B. R.; Jobe, T. L., Jr.; Neumann, D. B. *A report on some thermodynamic data for desulfurization processes*. 1981 September. 90 p. Available from: NTIS; PB 82-184904.

**Key words:** activity coefficients; binary aqueous systems; enthalpies of dilution; enthalpy; entropy; flue gas desulfurization; Gibbs energy osmotic coefficients; thermochemical tables.

Tables are presented here of values of thermochemical properties and processes at 298.15 K for substances of interest to DOE for flue gas desulfurization.

The substances covered are (1) the aqueous ions:  $\text{OH}^-$ ,  $\text{SO}_3^{2-}$ ,  $\text{HSO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{HSO}_4^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ,  $\text{H}^+$ ,  $\text{Mn}^{+2}$ ,  $\text{Fe}^{+2}$ ,  $\text{Mg}^{+2}$ ,  $\text{Ca}^{+2}$ ,  $\text{Na}^+$ , and  $\text{K}^+$ , and (2) solid, liquid, aqueous, and gaseous compounds or species formed from these ions.

The tables contain the following: 1. The thermochemical property values, enthalpy of formation,  $\Delta_f H^\circ$ , Gibbs energy of formation,  $\Delta_f G^\circ$ , entropy,  $S^\circ$ , and heat capacity,  $C_p^\circ$  all at 298.15 K, as well as the enthalpy difference between 298.15 K and 0 K,  $H^\circ - H^\circ_0$ , for the basic species cited above. 2. The predicted values for  $\Delta H^\circ$ ,  $\Delta G^\circ$ ,  $\Delta S^\circ$ , and  $\Delta C_p^\circ$  as well as  $\log K$  (equilibrium constant) for the processes, or reactions, of importance to DOE, calculated from (1). 3. The property values,  $\phi_L$ , the relative apparent molar enthalpy,  $\gamma_\pm$ , from the mean ionic activity coefficient, and  $\phi$ , the osmotic coefficient, for binary aqueous systems at 298.15 K, all as a function of concentration.

Some documentation for (2) and (3) is provided. All of the values given are consistent with the NBS TN 270 Series.

**NBSIR 81-2352.** Steihler, R. D. *Solar energy systems—Standards for rubber hose used with liquids above their boiling points*. 1981 September. 29 p. Available from: NTIS; PB 82-174202.

**Key words:** glycol antifreeze stability; heat transfer liquid; hose; hose immersion test; hose specification; rubber hose; solar energy systems.

Class AT hose in ASTM Standard D 3952-80, Specification for rubber hose used in solar energy systems, is specified for use with aqueous liquids above 100°C. The lining of this hose is subjected to immersion tests at 100°C. The purpose of this study is to determine whether immersion tests in aqueous liquids above maximum service temperature are necessary in the hose standard.

The results of an interlaboratory test indicate that Class AT hose should be subjected to immersion tests above maximum service temperature. By inference, Class N hose used with a volatile heat transfer liquid at a temperature above its boiling point should be similarly tested above maximum service temperature.

The study also indicates that ASTM Reference Coolant (ethylene glycol base) is not stable at 150°C. In addition to the hose lining, the stability of the heat transfer liquid above maximum service temperature must be determined to assure satisfactory performance of the system.

A proposed revision of ASTM D 3952 is included in the report. It provides for immersion tests above maximum service temperature of Class AT and Class N hose linings used with heat transfer liquids above their boiling points.

**NBSIR 81-2356.** Joseph, R. E.; Staples, B. R. *A compilation of thermodynamic and transport properties of aqueous potassium hydroxide*. 1982 January. 19 p. Available from: NTIS; PB 82-171091.

**Key words:** activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties.

A detailed compilation of sources of data for the thermodynamic and transport properties of aqueous potassium hydroxides are presented. All ranges of temperature, concentration, and pressure are included.

**NBSIR 81-2357.** Christopher, P. M. *Residential solar data center: Data dictionary/directory*. 1981 September. 99 p. Available from: NTIS; PB 82-178955.

**Key words:** automatic data processing; data dictionary/directory; residential buildings; solar data energy system; solar heating and cooling.

The Residential Solar Data Center project staff in the Center for Building Technology, National Bureau of Standards, maintains a computerized data base containing non-instrumented residential data from the DoE/HUD Solar Heating and Cooling Demonstration Program. This document provides a dictionary of data elements collected as part of the Residential Solar Program and a directory of the specific files which contain the data elements. This data dictionary/directory was produced by a computer program written in ASCII COBOL. The automated procedure is briefly described in an appendix.

**NBSIR 81-2360.** Hillhouse, D. L.; Leep, D. A. *Analysis of the calibration of metering CCVTs in a utility substation*. 1981 October. 53 p. Available from: NTIS; PB 82-209776.

**Key words:** calibration; CCVT; EHV substations; error sources; high voltage measurements; revenue metering.

This report presents the results of an investigation of unexpected variations in nine 500 kV metering CCVTs, tested for Gulf States Utilities at Baton Rouge, LA. These measurements were performed on three occasions—May 1979, March 1980, and December 1980.

On the first two occasions, six out of nine CCVTs were out of tolerance; on the third, four out of nine. More important, the changes between the first two occasions seemed to be correlated by phase, i.e., most of the devices on a given phase shifted in the same general direction and by similar amounts. When analysis failed to provide an explanation for this, the third set of measurements was undertaken.

Analysis of the three sets of data produced some evidence of a bias voltage in the 1979 data. Investigation of all plausible known sources of error in the NBS system, the substation, and the CCVTs themselves failed to produce a probable source for such a bias



voltage.

No evidence of consistent malfunction of the NBS system was found. Even allowing for a possible bias in one set of data, a majority of the CCVTs were still outside of metering tolerance. Continuous monitoring of a statistically significant number of operating CCVTs should be considered.

**NBSIR 81-2369.** Christopher, P. M.; Houser, A. O. **Residential solar data center: Data resources and reports.** 1981 October. 66 p. Available from: NTIS; PB 82-180845.

**Key words:** automatic data processing; data base; residential buildings; solar data base; solar energy systems; solar heating and cooling.

The Residential Solar Data Center (SDC) was responsible for the establishment and operation of a computerized data base containing non-instrumented residential data collected from the DoE/HUD Solar Heating and Cooling Demonstration Program. This document includes a summary of the history and background of the SDC and its role in the demonstration program, a list of the final computer reports which are available, sample pages of representative reports, and a description of the data files which comprised the solar data base.

**NBSIR 81-2372.** Wan, C. A.; Palla, R. L., Jr.; Harris, J. E. **Development of energy test methods for a dedicated water-heating heat pump.** 1982 January. 53 p. Available from: NTIS; PB 82-170069.

**Key words:** energy conservation; energy consumption; flow control valve; heat pump; stratification; test method; water heater.

Modifications of the DOE test procedure for water heaters "Uniform Test Method for Measuring the Energy Consumption of Water Heaters" were made to include a dedicated water heating heat pump, system equipped with a 50 gallon electric water heater tank. Also presented are laboratory tests and results which provided the basis for the test methods used. Tests included determination of recovery efficiency, standby loss, and water heater jacket loss—all under static or no-draw conditions—and a dynamic test in which water is withdrawn according to a "typical-use" schedule. Energy requirements predicted by the proposed (static) procedure were in good agreement with measured energy consumption for the dynamic test in limited testing.

**NBSIR 81-2376.** Christopher, P. M.; Charlton, L. **Residential solar data center: Grant reports.** 1981 September. 144 p. Available from: NTIS; PB 82-180910.

**Key words:** automatic data processing; computer reports; grant data; residential buildings; solar data base; solar energy system; solar hot water, space heating and cooling.

The Residential Solar Data Center project staff in the Center for Building Technology, National Bureau of Standards, has been responsible for the establishment and operation of a computerized data base containing non-instrumented residential data generated by the Solar Heating and Cooling Demonstration Program sponsored by the Department of Energy (DoE) and the Department of Housing and Urban Development (HUD). This document includes computer reports of data contained in the Grant file, one of six computer files comprising the data base. These reports contain data recorded on applications submitted to HUD by organizations or individual builders applying for grants to build solar energy systems in new and/or existing homes. Approximately 668 grants have been awarded in six award cycles.

**NBSIR 81-2379.** Powell, J. W.; Barnes, K. A. **Comparative analysis of economic models in selected solar energy computer programs.** 1982 January. 82 p. Available from: NTIS; PB 82-184995.

**Key words:** computer simulation models; Federal Life-Cycle Cost Rules; life-cycle cost analysis; net savings; solar energy computer program; solar energy economics; solar energy systems.

A variety of computer simulation models exists for the design and study of thermal performance and economic feasibility of solar domestic hot water and space heating systems. Several studies have

indicated that the thermal performance algorithms contained in the different models produce similar results. However, little comparative analysis has been done of the economic algorithms in these programs.

This report compares the economic evaluation models in five computer programs widely used for analyzing solar energy systems: F-CHART 3.0, F-CHART 4.0, SOLCOST, BLAST, and DOE-2. Differences in analysis techniques and assumptions among the programs are assessed from the point of view of consistency with the Federal requirements for life-cycle costing (10 CFR Part 436), effect on predicted economic performance and optimal system size, ease of use, and general applicability to diverse system types and building types. The FEDSOL program developed by the National Bureau of Standards specifically to meet the Federal life-cycle cost requirements serves as a basis for the comparison. Results of the study are illustrated in test cases of two different types of Federally owned buildings: a single-family residence and a low-rise office building.

The study indicated that none of the programs except FEDSOL fully conformed with the Federal requirements for life-cycle cost analysis of renewable energy projects. However, with considerable manipulation of data inputs and simplification of assumptions, they could provide similar predictions for one measure of economic performance, net present value savings.

**NBSIR 81-2380.** Petersen, S. R. **Economics and energy conservation in the design of new single-family housing.** 1981 August. 160 p. Available from: NTIS; PB 82-203639.

**Key words:** architecture; building design; cost-benefit analysis; economics; energy conservation; housing; insulation; space heating and cooling costs; space heating and cooling requirements.

This report investigates the extent to which certain energy conservation modifications to the envelope design of a new, single-family house are economically justified for a wide range of climates and projected energy costs. The report provides background information on those factors that give rise to space heating and cooling loads in buildings and examines in greater detail than in previous reports the thermal interdependencies within and among envelope components that can greatly affect heating and cooling loads. Economic criteria for determining a minimum life-cycle cost building envelope design are formulated and a priority-ranking method is developed to assist in the calculation of these designs. An expanded version of the NBS Load Determination Program is used to calculate the annual heating and cooling requirements and maximum heating and cooling loads for a 1200 square foot, wood-frame house having a wide range of thermal improvements in 14 geographic locations. The report also provides a methodology for interpolating these results to climatic conditions other than the 14 analyzed. The analysis demonstrates that the optimal envelope design configuration varies over a wide range depending on climate, energy costs, and modification costs.

**NBSIR 81-2393.** Liu, S. **Analysis of thermal comfort in a passive solar heated residence.** 1981 November. 45 p. Available from: NTIS; PB 82-180142.

**Key words:** ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall.

An analytical investigation was conducted on the thermal comfort conditions in a passive solar heated residence of the popular Trombe Wall configuration. The National Bureau of Standards Load Determination Program (NBSLD) was used to simulate the indoor thermal environment of an actual passive solar residence, using the Typical Meteorological Year (TMY) weather data tape as input at three locations of different climatic conditions. The relevant thermal comfort parameters such as the space air temperature, mean radiant temperatures, operative temperatures, radiant temperature asymmetry, and temperature drifts of the occupied zone, were computed for a prime heating month, a transition month, and a prime cooling month of a typical weather year at the three locations. These parameters were analyzed in accordance with the criteria specified in the recently revised ASHRAE Comfort Standard 55-81. It was found that for the specific passive solar residence analyzed, the upper boundary of the comfort envelope can be exceeded (overheating) during a typical clear day in the transition month of April unless a change of clothing



to summer wear is made during the daytime high solar radiation house. The upper boundary will be exceeded during a typical clear day in the prime cooling month of August for a person in typical summer clothing at all three locations unless the average air movement in the occupied zone is increased above the level of natural circulation, or the thermostat setting is reduced to a lower level, or both.

**NBSIR 81-2400.** Evans, D. D. Analysis of data from room fire test of parsons tables and comparison with laboratory test methods for flame spread and smoke generation, Volume I. 1981 November. 102 p. Available from: NTIS; PB 82-185307.

Key words: ASTM E162; fire tests; flame spread; plastics; smoke chamber; tables.

Data from a series of 18 room fire tests in which a Parsons table was the only combustible item were analyzed. Selected data from the tests were compared to laboratory fire test data from the ASTM E162 surface flammability test, and a modified smoke density test.

The flame spread index from the ASTM E162 test was not shown to be a dependable indicator of either the time for table fire involvement or room fire intensity. Results from the National Bureau of Standards smoke chamber using a MOD (mass optical density) method for data reduction were able to predict the smoke production rate and total smoke production from the table fires to within 34 percent and in several cases within 5 percent.

**NBSIR 81-2403.** Ehrstein, J. R.; Seabaugh, A. C. Gallium arsenide materials characterization: Annual report, October 12, 1978 to October 12, 1979. 1981 December. 38 p. Available from: NTIS; PB 83-141945.

Key words: contacts; gallium arsenide; potential profiling; spreading resistance.

Ohmic and Schottky barrier contacts for use in electrical characterization were examined both conceptually and experimentally with particular focus on the problems associated with ohmic contacts to semi-insulating GaAs. The conductivity type of the semi-insulating material, which can be either *n*- or *p*-type, was investigated by means of a potential profiling technique. In addition, the feasibility of spreading resistance measurements was examined and applied to both low resistivity bulk GaAs and ion-implanted semi-insulating substrate material.

**NBSIR 81-2409.** Sanderson, B. T.; Kruger, J. Bibliography of literature on underground corrosion of metals and alloys considered for use in the construction of containers for nuclear waste. 1982 January. 48 p. Available from: NTIS; PB 82-165275.

Key words: alloys; containers; corrosion; corrosion data; geothermal brines; metals; nuclear waste; underground.

This bibliography consists of references pertaining to the corrosion of metallic container materials for nuclear waste disposal. Five kinds of corrosion data are presented—general underground corrosion data that may apply to metallic nuclear waste containers; corrosion considerations in package design; metallic corrosion in geothermal brines; internal corrosion of nuclear waste containers for underground use; and external corrosion of nuclear waste containers for underground environments. Abstracts are provided for most references, and key words are included when there is no abstract. One hundred and sixteen references are presented.

**NBSIR 81-2411.** Pearl, M. H. An examination of the state of the art in inland waterways system lock research. 1982 February. 111 p. Available from: NTIS; PB 83-162727.

Key words: capacity; dam; lock; queue; simulation; waiting time.

Locks which pass waterborne traffic through dams act as bottlenecks and interfere with the free flow of traffic. Two complementary mathematical tools have been used to determine the maximum capacity of a lock and the operating procedures which achieve this capacity. These are i) computer simulations of traffic flows, and, ii) the mathematical theory of queues. A large-scale, multi-purpose simulation package was developed at the Pennsylvania State University and expanded by the Army Corps of Engineers. Several researchers have attempted to model the operation at a lock using

mathematical queueing theory. In addition, queueing theory has been applied to analyze traffic flow through a bottleneck on other modes of transportation. Also, queueing theory has been used to study problems which arise in the use of computer simulations.

**NBSIR 81-2413.** Russell, T. J. Production-compatible microelectronic test structures for the measurement of interface state density and neutral trap density. 1982 January. 41 p. Available from: NTIS; PB 82-182387.

Key words: avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures.

Interface states and oxide neutral traps are defects in metal-oxide-semiconductor (MOS) structures which adversely affect the operation of integrated circuits (IC). For very large scale integration (VLSI), the advanced techniques which are used to fabricate circuits with devices of submicrometer geometries expose the devices to ionizing radiation which can create these defects or alter the number of defects and their charge state and thus modify device operating characteristics. The physical identities of the defects which trap charge at the interface and in the bulk oxide are not well established. This means that one cannot *a priori* predict the behavior of the defects to a stress or fabrication process. Thus, it is desirable that the density of these defects be monitored routinely and that the measurement method used be easy to perform and fast and that it provide unambiguous results and be compatible with a production environment. The purpose of this study is to identify production-compatible measurement methods which can be used for routine measurement of neutral trap density and interface trapped charge. This study reviews the application of existing methods for quantifying the number of these defects. Methods determined to be most appropriate for the stated purpose are discussed in detail.

**NBSIR 81-2416.** Pielert, J. H.; Chapman, R. E.; Hall, W. G. Application of an equivalency methodology to building rehabilitation: A pilot study. 1982 January. 91 p. Available from: NTIS; PB 82-185976.

Key words: applied economics; building codes; health and safety; housing; mathematical programming; rehabilitation; renovation.

With increased emphasis on the re-use of existing buildings, new approaches must be developed to assist regulators in making code related decisions. The application of performance criteria to building rehabilitation provides flexibility in the use of technically sound design alternatives in lieu of prescriptive provisions which may be restrictive. This report presents the results of a pilot study on the application of an equivalency methodology in achieving regulatory compliance. The use of such a methodology is particularly attractive in this area because prescriptive type provisions have been shown to constrain rehabilitation activities, and in some cases, may be mutually contradictory. Regulatory requirements were chosen so as to explicitly incorporate conflicting requirements as affecting the design of windows and doors—illumination, ventilation, egress and security. The methodology is computerized to allow the selection of least-cost means of achieving compliance with these requirements. A prototypical townhouse is evaluated using the pilot equivalency methodology and optimal compliance strategies are identified and compared with the cost of prescriptive compliance. The results of the study produced potential savings ranging from 20 to 35 percent depending on the initial conditions of the building.

**NBSIR 81-2420.** Kusuda, T.; Mizuno, M.; Bean, J. W. Seasonal heat loss calculation for slab-on-grade floors. 1982 March. 49 p. Available from: NTIS; PB 82-182379.

Key words: building heat transfer; DoE-2 energy analysis computer program; monthly average earth temperature; thermal response factors.

In order to facilitate an efficient slab-on-grade heat transfer calculation on a comprehensive energy analysis program such as DoE-2, BLAST and NBSLD, heat transfer calculations for slab-on-grade floors are reviewed. The computational procedure based on the Lachenbruch method is studied in depth to generate monthly average temperatures at a given depth below the floor slab. The data



generated by the Lachenbruch method are then used to develop a simplified procedure for determining the monthly average earth temperatures below the floor slab. These monthly average temperature data can be used for the hourly response factor analysis of floor-slab heat transfer.

**NBSIR 81-2422.** Ings, J. B.; Brown, P. W. *Factors affecting the service lives of phase change storage systems.* 1982 February. 19 p. Available from: NTIS; PB 83-137174.

**Key words:** crystal growth; encapsulants; failure mechanisms; nucleating agent; phase change storage; service life prediction.

Phase change storage systems currently in use or which are in the advanced stages of development are identified. Various possible modes of degradation which may affect service lives are considered. Specifically, the effects of crystal growth, crystal segregation, supercooling, corrosion and thermal decomposition are discussed. The generic basis for the development of performance tests for inorganic phase change materials is described.

**NBSIR 81-2423.** Bray, G.; Lipsett, R.; Bail, W.; Berman, V. *Compiler-based programming support capabilities.* 1982 January. 70 p. Available from: NTIS; PB 82-154378.

**Key words:** compilers; dynamic analysis; programming aids; software development; software engineering; software tools; static analysis.

An effort to determine a set of features offered by program analysis and testing tools that could be feasibly implemented in a compiler is reported. Currently, program analysis and testing tools offer features that require syntactical analysis of a program in a manner similar to compilers. Much of the information that is generated during compilation could be used to aid program development in other ways. It was the goal of this effort to identify a set of software tool features and develop a methodology for combining these into a compiler.

**NBSIR 81-2424.** Parks, E. J.; Johannesen, R. B.; Brinckman, F. E. *Characterization of organometallic polymers by chromatographic methods and nuclear magnetic resonance.* 1981 December. 40 p. Available from: NTIS; PB 82-151465.

**Key words:** atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin.

Organometallic polymers (OMP) are an increasingly important class of marine surface antifouling agent undergoing intensive development by the U.S. Navy. Candidate OMP's have been characterized at NBS by size exclusion chromatography (SEC) coupled with tin-specific graphite furnace atomic absorption spectroscopy (GFAA) as well as by Fourier transform nuclear magnetic resonance (FT-NMR). The key molecular parameters of many OMP's, the kinetics of formation of a typical copolymer, and the effects of different concentrations of free radical initiators on the formation of a copolymer in a well-stirred reaction system have all been characterized by means of SEC-GFAA chromatograms. FT-NMR spectra of  $^{119}\text{Sn}$  have given kinetic information in good agreement with that obtained by SEC-GFAA. Both chemical shift and linewidth of the tin NMR signal have been shown to have an unusually large solvent and temperature dependence. Directions for future research on OMP's are discussed.

**NBSIR 81-2427-1.** Parker, W. J. *Calculations of the heat release rate by oxygen consumption for various applications.* 1982 March. 41 p. Available from: NTIS; PB 82-192956.

**Key words:** calorimeters; fire tests; heat release rate; oxygen consumption; room fires.

The oxygen consumption technique is emerging as a powerful tool for determining the heat release rate in a number of diverse fire test applications, including room fire tests, fire endurance tests, the ASTM E 84 tunnel test, and various heat release rate calorimeters. Depending upon the constraints of the test, the accuracy required, the availability of instrumentation and computational facilities, and the willingness to put up with experimental inconveniences, a number of instrumentation options have been considered—each of which require

different calculational procedures. The purpose of this report is to develop the equations in a general way and show how to adapt them to various applications such as: closed systems versus open systems; trapping carbon dioxide before it reaches the oxygen analyzer, measuring it, or assuming that it is equal to the reduction in oxygen concentration; ignoring carbon monoxide or measuring it; accounting for the density of the exhaust gases or assuming that it is the same as for air; using a high temperature oxygen cell which measures the oxygen concentration in the exhaust duct directly or a paramagnetic analyzer for which corrections must be made for water vapor trapping; taking into account or ignoring the ambient concentration of water vapor and carbon dioxide; and, improving the accuracy for open systems by monitoring the water vapor in the exhaust duct. The equations developed here should be useful to anyone setting up a new system and will provide a means of calculating the errors which might be expected when simplified procedures are used.

**NBSIR 81-2434.** Mulroy, W. J. *Method of testing, rating and estimating the seasonal performance of ground water source heat pumps.* 1982 November. 54 p. Available from: NTIS; PB 83-137778.

**Key words:** central air conditioners; heat pumps; rating procedure; seasonal cost of operation; test method.

The National Bureau of Standards has made a study of the part-load and seasonal performance of residential ground water source heat pumps operating in both heating and cooling modes. This document outlines methods for testing and rating these units which account for the variation in performance due to part-load operation and change in source water temperature. A calculation procedure is presented which can be used to estimate the seasonal performance and seasonal cost of operation of residential ground water source heat pumps.

**NBSIR 81-2436.** Howell, B. F.; Chesler, S.; Hilpert, L.; Reeder, D. J. *Low molecular weight leachables from medical grade polymers.* 1982 April. 36 p. Available from: NTIS; PB 82-205766.

**Key words:** enzymatic assay; gas chromatography/mass spectrometry; leachables; mammary prosthesis; polymeric implants; prolyl hydroxylase.

Four medically important polymeric materials (silicone polymer from mammary prostheses, polyurethane, polyethylene, and polycarbonate) were placed in contact with water for time periods ranging from four hours to seven days. Substances leaching into water were separated by extraction with methylene chloride, or by evaporation of water, and identification of species in the leachate was attempted by a number of analytical techniques, with extensive use of combined gas chromatography/mass spectrometry (GC/MS). Low molecular weight fragments of dimethylsiloxane were identified from mammary prosthesis gel. Spectra are also included for leachate from the other three polymers; identification of these compounds is still in process.

Prolyl hydroxylase and tritium-labeled procollagen substrate were prepared from chick embryos, and an enzyme activity assay system was developed with use of Bio-Rad AG 50W-X8 cation exchange resin. No effect on enzyme activity was seen when silicone gel leachate was added to the assay mixture.

**NBSIR 81-2438.** Paulsen, R. L. *Human behavior and fire emergencies: An annotated bibliography.* 1981 December. 133 p. Available from: NTIS; PB 82-170168.

**Key words:** bibliographies; evacuation; fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; sprinkler systems.

This report contains an annotated listing of 161 selected references pertaining to human behavior and fire emergencies. The scope is broad: the references cover the full range of behavioral responses through the different stages of a fire emergency in the context of a variety of occupancy settings. Health care institutions are the most frequently represented occupancy type. Many research approaches are included; e.g., case studies of individual incidents, survey studies of large numbers of incidents, theoretical analyses and representations of the fire situation, computer models, literature surveys, and psychological studies of selected populations. The work of researchers from many nations, including the United States, Canada, Great Britain, Japan, West Germany, France, Belgium, and the



U.S.S.R., is referenced. Annotations for papers from the first two international conferences on human behavior in fires (March 1977 and October 1978) are contained in this bibliography. There is a topical index to provide the reader with a preliminary guide to those references regarding a particular occupancy type, research approach, design feature, or category of behavioral response. An introductory essay provides an overview of the field of human behavior and fires and develops some common themes found in the literature.

**NBSIR 81-2440.** Rockett, J. A. *Modeling of NBS mattress tests with the Harvard Mark V Fire Simulation*. 1982 January. 75 p. Available from: NTIS; PB 82-176082.

Key words: fabric flammability; fire models; fire tests; home fires; hospitals; mattresses; nursing homes; room fires; smoldering.

NBS burned eleven mattresses made up with bedding in two different rooms, typical of a residential bedroom and a nursing home patient room, respectively. Seven of the mattresses flamed and burned vigorously, the other four were of a construction or so heavily flame inhibited that they only smoldered. The burning behavior of the seven that flamed was modeled with the Harvard Mark V fire simulation. The experimental burn behavior for tests conducted in one room was well reproduced using only total weight of combustible, surface area and heat of combustion. Smoke production values were found to have little effect on the predicted behavior except for the smoke production itself. Fires in a second room, whose ventilation was intentionally restricted by the configuration of the adjoining space, could not be as well reproduced by the present, single room fire model.

During this study several changes were made to the simulation. The most significant change was the inclusion of mixing of the hot, exiting fire gases with the cold incoming air. As a part of this, the inter-layer radiation exchange was reformulated to include the effect of smoke contamination of the lower layer. The reformation of the radiation model has a marked effect on the predicted upper layer gas temperatures, generally improving the quality of the simulation.

**NBSIR 81-2442.** Fivozinsky, S. P., ed. *Technical activities 1981. Office of Standard Reference Data*. 1981 December. 83 p. Available from: NTIS; PB 82-165820.

Key words: data compilation; energy and environmental data; evaluated data; materials data; standard reference data; technical activities 1981; thermochemical and thermophysical data.

The Office of Standard Reference Data is one of six program offices in the National Measurement Laboratory, National Bureau of Standards. The Standard Reference Data Program develops and disseminates data bases of critically evaluated physical/chemical properties of substances. These data bases are available through NBS and private publications, on magnetic tape, and from on-line retrieval systems.

The Office of Standard Reference Data is responsible for management and coordination of the program. Work is carried out through a decentralized network of data centers and projects referred to as the National Standard Reference Data System (NSRDS). This volume summarizes the activities of the program for the year 1981.

**NBSIR 81-2443.** Bales, E. L. *Plan for a round robin of hot boxes*. 1982 February. 39 p. Available from: NTIS; PB 82-183914.

Key words: ASTM C-236; calibrated and guarded hot boxes; interlaboratory round robin tests; thermal conductance of building sections.

A plan for an interlaboratory round robin series of tests sponsored by the American Society for Testing and Materials (ASTM) using calibrated or guarded hot-box equipment is described. These testing methods are designed to measure the thermal conductance of full-scale building sections such as walls, roofs and floors. Results from about 25 hot boxes in the U.S. and Canada are expected to produce improved calibration techniques and repeatability and uncertainty information useful for improving ASTM specifications.

**NBSIR 81-2444.** Klote, J. H. *Smoke movement through a suspended ceiling system*. 1982 February. 83 p. Available from: NTIS; PB 82-195520.

Key words: ceiling systems; hazard analysis; hospitals; interstitial space; mattresses; smoke control; smoke exhaust; smoke movement; ventilation systems.

A series of full-scale tests were conducted to evaluate smoke movement through a suspended ceiling and into interstitial space of a hospital type facility. A test facility specifically constructed for this project is described. The test series consisted of one smoke candle test and 12 fire tests including both smoldering and flaming fires. Smoke movement through the suspended ceiling system was evaluated in terms of the total smoke movement through the test facility. The effects of ventilation and smoke exhaust on smoke concentration in the test facility were investigated.

**NBSIR 81-2445.** Tighe, N. J.; Wiederhorn, S. M. *Application of proof testing to brittle materials at high temperatures*. 1981 December. 203 p. Available from: NTIS; PB 82-183005.

Key words: deformation maps; high temperatures; proof testing; reliability; silicon nitride; structural ceramics.

The report contains the publications prepared during the contract period. The publications concern the theories of proof testing for assuring reliability and present experimental results obtained on silicon nitride tested at 1200°C. The important conclusion from the research is that the flow population which causes failure changes during exposure and produces new population. A approach which includes dynamic flow population was developed and is included in the report. The experimental data is presented in the form of a map which displays strength vs. time under load.

**NBSIR 81-2448.** Roberts, W. E.; Masters, L. W.; Clark, E. J. *Effects of air mass and integration methods on results for optical property measurements of solar cover plate and absorber materials*. 1982 January. 47 p. Available from: NTIS; PB 82-165184.

Key words: air mass; ASTM E 424; integrating sphere spectrophotometer; reflectance; selected ordinate; solar absorber materials; solar cover plates; transmittance; weighted ordinate.

This study was undertaken to compare methods of calculating the transmittance of cover plate materials and the reflectance of absorber materials. Optical data were obtained for both aged and unaged test specimens using an integrating sphere spectrophotometer. The data were integrated using: (1) the weighted and selected ordinate methods in ASTM E 424, Method A, at air mass 2.0, and (2) the selected ordinate method at air mass 1.5 and 1.0. The solar reflectance and solar transmittance values calculated using the various methods are presented in this report along with discussions of the impact of the data in terms of possible revisions to ASTM E 424.

**NBSIR 81-2450.** Mahajan, B. M. *Experimental investigation of transport of discrete solids with surge flows in a 10.0 cm-diameter partially filled pipe*. 1982 January. 65 p. Available from: NTIS; PB 82-178724.

Key words: equation; flow; horizontal; motion; partially-filled pipe; slope; solid; stream-depth; surge; transport; velocity; water.

This report presents the results of a series of experiments on the transport of discrete solids with surge flows in a partially filled slightly pitched horizontal pipe. The experimental apparatus, instrumentation, and procedures are described.

The experiments were conducted using a cylindrical solid in a 10.0-cm (4-in) diameter pipe. The water surge flows were obtained by discharging different volumes of water into the pipe from a falling head open container which simulated a water closet.

For each experiment, flow induced solid velocities and stream depth histories at various locations along the length of the pipe were measured. The effects of water volume used, pipe slope, and size of the solid on the solid velocities were examined. Solid velocities were compared with the maximum water velocities estimated from the stream depth histories. Also, the distance traversed by the solids in the pipe were measured for those cases in which the solids did not clear the pipe.

The solid velocity increased with an increase in water volume used, a decrease in the size of the solid, and an increase in the pipe slope. The solid velocity in the initial reach of the pipe was less than the maximum water velocity; and the solid velocity approaches the maximum water velocity as the solid traveled downstream, except for



some experiments with small water volumes.

The distance traversed by the solid increased with an increase in water volume, a decrease in the size of the solid, and an increase in the pipe slope.

The available data are too few to indicate any definitive conclusion; however, a comparison of data on solid transport in 7.6-cm (reported in a prior publication) and 10.0-cm pipe suggests that the 7.6-cm pipe may be slightly better for transport of solids with small water volumes than the 10.0-cm pipe.

**NBSIR 81-2453.** Lee, B. T. **Quarter-scale modeling of room fire tests of interior finish.** 1982 March. 74 p. Available from: NTIS; PB 83-159129.

Key words: fire growth; flashover; heat release rate; physical modeling; room fires; scale models.

A technique for modeling fire build-up in rooms with combustible interior finish was refined to achieve closer simulation of full-scale fire development. Fire experiments were performed in one-quarter scale model rooms and full-scale rooms having a doorway opening. The interior finish test materials were nitrile foam rubber, fibrous glass, and plywood; a gas burner was employed as the fire source in a rear corner of the room. It was necessary to lower the doorway opening in the model by as much as 14 percent to obtain flashover with the same equivalent heating rate that produced flashover in the full-scale test. At the same time, the width of the doorway in the model was increased appropriately to maintain the same volumetric air flow rate. The effects of burner location and heating rate on flashover in a well-insulated room were also studied to help select a suitable ignition source size and placement for testing of interior finish materials. The minimum heating rate needed to cause flashover in a  $3 \times 3 \times 2.3$  m high room lined with fibrous glass and having a  $0.73 \times 1.93$  m high doorway opening would entail placement of the heat source in a back corner with the source having a heat release rate of 300 kW. A corresponding rate for the quarter-scale room would be 19 kW.

**NBSIR 81-2460.** Kao, J. Y.; Snyder, W. J. **Application information on typical hygrometers used in heating, ventilating and air conditioning (HVAC) systems.** 1982 January. 43 p. Available from: NTIS; PB 83-137158.

Key words: building energy monitoring; heating, ventilating and air-conditioning controls; humidity; humidity control; humidity measurement; humidity sensor; hygrometer.

This report provides hygrometer selection information for application in heating, ventilating and air-conditioning (HVAC) systems. A general review of hygrometer literature has been provided and the most commonly used ones for HVAC are discussed. Typical hygrometer parameters are listed to indicate the type of performance that can be expected. Laboratory test results of self-regulating, salt-phase transition hygrometers are presented and discussed in detail.

**NBSIR 81-2466.** Nau, D. S. **Expert computer systems, and their applicability to automated manufacturing.** 1982 February. 110 p. Available from: NTIS; PB 83-126623.

Key words: AMRF; artificial intelligence; automated manufacturing; expert systems; knowledge-based systems; knowledge engineering; knowledge representation; problem solving; process planning.

This paper contains two main parts: a tutorial on techniques used in expert systems, and some recommendations for an automated process planning system for the Automated Manufacturing Research Facility at the National Bureau of Standards (NBS).

The tutorial portion of the paper consists of Sections 2, 3, and 4. Sections 2 and 3 discuss AI problem solving and knowledge representation techniques. Section 4 describes ways in which these techniques have been used to build computer systems which achieve a high level of performance on problems which normally require significant human expertise for their solution.

Section 5 contains a summary of the activities required for process planning in the Automated Manufacturing Research Facility (AMRF) at NBS, and recommendations for how to accomplish these activities. Section 6 contains recommendations for how an expert system could be designed to perform a process planning activity called process selection.

**NBSIR 82-1658.** Arvidson, J. M.; Sparks, L. L.; Steketee, E. **Mechanical properties of concrete mortar at low temperatures.** 1982 February. 9 p. Available from: NTIS; PB 82-185125.

Key words: compressive strength; concrete mortar; elongation; low temperature; maximum strength; mechanical properties; yield strength; Young's modulus.

This report includes test results conducted at ambient (295 K), dry-ice and alcohol (195 K), liquid nitrogen (76 K), and liquid helium (4 K) temperatures. The compressive properties reported are Young's modulus, yield (at 0.2% offset) and maximum strengths, and elongation (elastic and plastic). Test specimens (5.1 cm diameter  $\times$  10.2 cm) were instrumented with a specially designed, diametrically opposed, cryogenic strain-gaged extensometer that minimizes possible errors due to specimen bending during the test.

**NBSIR 82-1659.** Ma, M. T.; Arthur, M. G. **A study of the electromagnetic fields distribution inside buildings with apertures excited by an external source.** 1982 February. 123 p. Available from: NTIS; PB 82-193418.

Key words: aperture; cavity; equivalence principle; field distribution; slot.

Two special cases of the penetration of electromagnetic fields into a cavity, building or box are formulated and analyzed. One is to consider the case of a lossy cavity with small apertures in free space, based on an application of the equivalence principle and the use of a generalized network formulation. It is found that the field strength at the aperture center is approximately inversely proportional to the square-root of the conductivity of the cavity walls and that high field levels can exist inside the cavity under certain physical conditions. The second case is to treat the problem of large buildings with large apertures on a practical lossy ground by a combination of theoretical approach and measurement data. Field levels inside the building for this latter case depend on the transmitter power, the transmitter-to-building distance, the ground conductivity, and the measurement antenna height relative to that of the transmitter.

**NBSIR 82-1660.** Yamashita, H.; Arp, V. D. **Computation of two-dimensional time-dependent natural convection of compressible fluid in a rectangular enclosure.** 1982 March. 45 p. Available from: NTIS; PB 82-198797.

Key words: compressible fluid motion; convection; finite difference approximation; heat transfer; natural convection; nonlinear convection; numerical integration; transient fluid motion; transient heat transfer.

Studies of natural convection processes generally assume an incompressible fluid wherein the density is a function of temperature only (the Boussinesq approximation). However, local pressure gradients caused by rapid variations in the heated wall temperature cannot be described within this approximation. These time-varying gradients cause fluid motions which perturb the quasi-static natural convection process. In this study, we describe a numerical analysis procedure which includes compressibility effects and allows computation of transient fluid motions during onset of natural convection. Details of the computational procedure and preliminary results for one geometry are given.

**NBSIR 82-1664.** Sparks, L. L. **Thermal conductivity of a polyurethane foam from 95 K to 340 K.** 1982 March. 22 p. Available from: NTIS; PB 82-194150.

Key words: convection; foam; gas conduction; guarded-hot-plate; insulation; low temperature; radiation; solid conduction; thermal conductivity.

Values of thermal conductivity for a  $32 \text{ kg/m}^3$ ,  $\text{CCl}_4\text{F}$  blown polyurethane foam are presented in the temperature range from 95 to 340 K. These data were obtained using a guarded-hot-plate apparatus (ASTM C 177). The apparent conductivity is discussed in terms of contributions from radiation and solid and gas conduction. Heat transfer via gas convection is not significant when the cell diameters are less than approximately 3 mm; cell dimensions of the thermal conductivity specimen are on the order of 0.5 mm.



**NBSIR 82-2401.** Armstrong, G. T.; Jobe, T. L., Jr. Heating values of natural gas and its components. Conversion of values to measurement bases and calculation of mixtures. 1982 August. 164 p. Available from: NTIS; PB 82-259375.

Key words: calorific value; enthalpy of combustion; estimation from composition; gaseous fuel mixtures; heating value; hydrocarbon gases; ideal gas; real gas; reference measurement conditions.

The standard enthalpies of combustion of the pure hydrocarbons  $C_1$  to  $C_6$  at 298.15 K and 101 325 Pa selected from the literature, with reference to a more detailed document, are used to derive heating values for the ideal gas and the real gas on molar, mass, and volumetric bases at five reference conditions involving other temperatures and pressures. Values can be obtained at both dry and water saturated conditions. The second virial coefficients and their first derivatives are used to calculate the effects of nonideality. Procedures are given and illustrated for calculating the heating values of mixtures from the composition and the data given for the pure compounds. The relationships between the quantities presented in the tables are illustrated by charts. A procedure is given for estimating the uncertainties of the calculated results.

**NBSIR 82-2449.** Berger, H.; Mordfin, L., ed. Technical activities 1981, Office of Nondestructive Evaluation. 1982 January 125 p. Available from: NTIS; PB 82-179003.

Key words: acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; and ultrasonics.

This is the fourth in a series of annual reports describing the technical activities of the nondestructive evaluation program at the National Bureau of Standards.

**NBSIR 82-2451.** Berger, M. J.; Seltzer, S. M. Tables of energy-deposition distributions in water phantoms irradiated by point-monodirectional electron beams with energies from 1 to 60 MeV, and applications to broad beams. 1982 January. 57 p. Available from: NTIS; PB 82-178716.

Key words: dosimetry; electrons; Monte Carlo; point-monodirectional beams; superposition; treatment planning.

This report presents tables of elementary three-dimensional absorbed-dose distributions in a water phantom irradiated by monoenergetic, point-monodirectional electron beams. Such distributions have been obtained by the Monte Carlo method for 14 beam energies from 1 MeV to 60 MeV. The tabulated results can be applied to the determination of absorbed-dose distributions from parallel beams of arbitrary finite cross section. The beam of interest is treated as a superposition of point-monodirectional beams, and the absorbed-dose distribution is obtained as a corresponding superposition of elementary absorbed-dose distributions. By way of example, the tabulated data are used to obtain (1) depth-dose curves and practical ranges in broad-beam geometry, and (2) central-axis depth-dose curves, radial distributions of absorbed dose, and isodose patterns for beams with finite circular cross section.

**NBSIR 82-2454.** Maximon, L. C.; Ganz, E.; Aniel, T.; de Miniac, A. Polarized tagged photons. An analysis of the differential cross section for polarized bremsstrahlung in the range of interest for a tagged photon system. 1982 January 128 p. Available from: NTIS; PB 82-177288.

Key words: Bethe-Heitler cross section; bremsstrahlung monochromator; photonuclear research; polarized bremsstrahlung differential cross section; polarized photon beams; tagged photon method.

We consider in detail the differential cross section for polarized bremsstrahlung for angles and energies in the range of interest for a tagging system and derive a high energy, small angle approximation for this cross section. For photons polarized perpendicular and parallel to the production plane these are given by eqs (I.2) and (I.3). We use these approximations to determine the maxima and minima of the cross sections for these two polarization states,  $d\sigma_{\perp}$  and  $d\sigma_{\parallel}$ , and to evaluate these cross sections at the extrema. It is shown that both  $d\sigma_{\perp}$  and  $d\sigma_{\parallel}$  have a very sharp dip in the region of small momentum

transfers. However, their behavior in the region of the dip, as a function of the azimuthal angle  $\phi$ , is quite different over most of the photon spectrum (condition (VI.33)). The cross section  $d\sigma_{\perp}$  behaves similarly to the cross section for unpolarized photons in that as  $\phi$  increases, the sharp dip vanishes, the minimum fuses with the second maximum, and the cross section then has only a single maximum. In contrast, the sharp dip in the cross section  $d\sigma_{\parallel}$  remains as  $\phi$  increases, provided condition (VI.33) is satisfied. This results in rather large polarizations in the region of the dip as shown in figs. 3(a)-3(h). Coulomb corrections to the Born approximation are considered, and do not fill in these dips.

**NBSIR 82-2457.** Domalski, E. S.; Churney, K. L.; Reilly, M. L.; Kirklin, D. R.; Ledford, A. E.; Thornton, D. D. 25 gram capacity combustion flow calorimeter. 1982 March. 49 p. Available from: NTIS; PB 82-200536.

Key words: enthalpy of combustion; flow calorimetry; municipal solid waste; refuse; refuse-derived-fuel; 25 gram capacity flow calorimeter.

A new calorimeter is being developed at the National Bureau of Standards to determine the enthalpies of combustion of kilogram-size samples of municipal solid waste (MSW) in flowing oxygen near atmospheric pressure. The organic fraction of 25 gram pellets of highly processed MSW has been burned in pure oxygen to  $CO_2$  and  $H_2O$  in a small prototype flow calorimeter. The carbon content of the ash and the uncertainty in the amount of CO in the combustion products contribute calorimetric errors of 0.1 percent or less to the enthalpy of combustion.

**NBSIR 82-2458.** Rawie, C. C. Benefits and costs of improved measurements: The case of integrated-circuit photomask linewidths. 1982 May. 81 p. Available from: NTIS; PB 82-217183.

Key words: accurate measurements; benefit-cost analysis; cost savings; economic analysis; photomask linewidth measurements; semiconductors.

Accurate dimensional measurements are vital to quality control in the semiconductor industry. This paper presents a method for estimating the dollar cost-savings from improving integrated-circuit photomask linewidth measurements. The method is illustrated with a case study of a hypothetical semiconductor device manufacturer who uses a Standard Reference Material (SRM) developed at the National Bureau of Standards for optical microscope calibration.

Benefits of investing in improved photomask linewidth measurements include reducing disputes between mask maker and mask customer, reducing waste of good photomasks, and increasing device yields. For the hypothetical manufacturer described in the study, these benefits were much greater than costs of implementing the new measurement procedures.

While the model is tailored to photomask linewidth measurements, its concepts can be applied to many other types of measurements.

**NBSIR 82-2469.** Lee, B. T. Effect of ventilation on the rates of heat, smoke, and carbon monoxide production in a typical jail cell fire. 1982 March. 84 p. Available from: NTIS; PB 82-194168.

Key words: fire growth; fuel load; heat release rate; prison cell fire; smoke.

The rates of heat release and smoke development from a fire in a typical prison cell configuration were examined under four doorway ventilation conditions. Peak heat release rates varied from about 4500 kW for a 3.34 m<sup>2</sup> doorway opening down to 340 kW for a 0.17 m<sup>2</sup> opening. However, the total and rate of smoke generation were greater with the small opening. The peak carbon monoxide production rate varied from 0.03 kg/s for the large opening to 0.01 kg/s for the smallest opening. The quantity of carbon monoxide generated, however, was highest for the smallest opening with 5.3 kg produced over the fire duration of 1800 s. During the peak fire development in the configuration with the larger openings, temperatures inside the room reached about 1000°C with roughly two-thirds of the heat lost to the cell room boundaries. Peak thermal fluxes inside the room generally exceeded the ignition threshold value of about 20 kW/m<sup>2</sup> for clothing, bedding, and other light combustible fuel for all of the tests.



**NBSIR 82-2471.** Wilson, C. L.; Blue, J. L. **CS1: A two-dimensional finite element charge-sheet model of a short-channel MOS transistor.** 1982 April. 61 p. Available from: NTIS; PB 82-205709.

**Key words:** elliptic solvers; finite elements; interactive graphics; MOS transistor.

A two-dimensional charge-sheet model for short-channel MOS transistors has been developed. The unique feature of the model is that the effect of channel inversion layer charge is included as a nonlinear integral boundary condition on the two-dimensional electrostatic field in the transistor. The average inversion layer charge density and source-drain current are obtained directly from the model rather than from the electron density or electron quasi-Fermi level. The model retains all of the physical detail of more complex two-dimensional models such as sensitivity to source-drain profile shape, channel profile, and oxide field shape. This allows the model to represent the changes in drain current associated with short-channel effects while still allowing simple comparison with long-channel models. For long-channel transistors, the results of this model are identical to Brews' long-channel charge-sheet model. The accuracy of this model is verified by modeling a sequence of transistors with channel lengths between 4.6 and 1.1  $\mu\text{m}$ . In short-channel transistors, effects previously attributed to high field mobility are explained by simple two-dimensional electrostatics.

The simulations produced using this model have been compared to experimental measurements on an array of n-channel MOSFETs; the model is in good agreement for transistors with channel lengths as short as 1.1  $\mu\text{m}$ . In this verification process, the model represented accurately the onset of subthreshold current, channel-length-induced threshold voltage offset, and drain-field-induced output conductance changes.

From studies of numerical accuracy, we conclude that the charge-sheet model can easily simulate drain current with an accuracy which exceeds that required for most applications. To obtain 5-percent accuracy for drain current, a 146 element mesh is sufficient. Refinement of the 146 element mesh to a 455 element mesh gives a current which is accurate to 0.16 percent. Average computer time for a high accuracy solution is 2.5 min on a DEC-20.

The numerical solutions were obtained using general-purpose software for solving elliptic partial differential equations. Problems with exact solutions have been solved to test the correctness and accuracy of the codes. Also, the physics included in this model and the geometry of the transistor can be easily changed. The finite element method used allows refinement of oblique triangles which is important in achieving computational efficiency. The program is portable and has been run on a DEC-20, a VAX 11/780, a Cyber 175, and a Univac 1108.

**NBSIR 82-2472.** Chang, S. S.; Senich, G. A.; Smith, L. E. **Migration of low molecular additives in polyolefins and copolymers.** 1982 March. 259 p. Available from: NTIS; PB 82-196403.

**Key words:** antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; oligomers; polyethylene; polypropylene; radiotracer.

Food packaging is an inseparable part of modern life. Any substance that migrates from the packaging material into foods is viewed as indirect food additives. In connection with toxicological knowledge, it is important to know the amount of such indirect food additives expected to be present in the food during storage and processing. This program, sponsored by the Bureau of Foods of the Food and Drug Administration is to provide theoretical models, reliable data base, methodology to study the migration phenomena and to provide reasonable worst-case estimates for the concentrations of the indirect additives in food. In this final report we present the results of approximately 250 completed migration experiments based on radiotracer techniques on the migration of low molecular weight hydrocarbons and antioxidants from polyethylene, polypropylene and ethylene-vinyl acetate copolymers. Results of a study for the determination of relative diffusion coefficients of several probe molecules in the polyethylene melt by inverse gas chromatography are also presented. Based on these studies, ethanol appears to be a far more reasonable food-oil stimulating solvent than n-heptane. Other pure mixed triglycerides may also be considered as food-oil stimulating solvents, however they may pose the same analytical difficulties as that of the food oil itself.

**NBSIR 82-2473.** McCaffrey, B. J.; Cox, G. **Entrainment and heat flux of buoyant diffusion flames.** 1982 February. 36 p. Available from: NTIS; PB 82-196296.

**Key words:** buoyancy; cross-correlation; diffusion flames; entrainment; heat flux; radiation; turbulence.

Measurements of the vertical component of velocity in buoyant diffusion flames from extended sources by both cross-correlation and pressure probe techniques incorporating time-average signal processing appear to overestimate the transverse size of these systems based on a heat balance using measured mean flux. By utilizing measurements of the radiative fraction of the flames, and forcing a mean flux heat balance, estimates of the transverse variation of velocity are obtained and expressions for flame entrainment and convective heat flux are determined. The use of mean values is seen to lead to both overestimates as well as underestimates of total flux due to turbulent transport.

**NBSIR 82-2474.** Hurley, C. W.; Ryan, J. D.; Phillips, C. W. **Performance analysis of the Jersey City total energy site: Final report.** 1982 August. 385 p. Available from: NTIS; PB 82-260381.

**Key words:** absorption chillers; boiler performance; central utility plant; diesel engine performance; engine-generator efficiency; environmental impact; heat recovery; total energy system.

Under the sponsorship of the Department of Housing and Urban Development (HUD), the National Bureau of Standards (NBS) gathered engineering, economic, environmental, and reliability data from a 486 unit apartment/commercial complex located on a 6.35 acre (2.6 hectare) site in Jersey City, New Jersey. The complex consists of four medium to high rise apartment buildings, a 46,000 ft<sup>2</sup> (4300 m<sup>2</sup>) commercial building, a school (kindergarten through third grade), a swimming pool, and a central equipment building.

The construction of the complex was started in 1971, and a decision was made by HUD to design the central equipment building to meet both the thermal and electrical energy demands of the site. The necessary equipment was installed to recover the waste heat from diesel engines driving the generators making the central equipment building a total energy (TE) plant. Absorption type chillers were also installed in the central equipment building. This TE plant has been serving the complex since January 1974.

The National Bureau of Standards was responsible for designing and installing the instrumentation and a data acquisition system (DAS) to determine fundamental engineering data from the plant and site buildings. The DAS was put on line in April 1975. The raw data from the DAS was processed by a minicomputer at NBS to obtain a broad spectrum of engineering results. This report describes these systems and presents the appropriate data and a performance analysis of the plant and site. The analysis of the data indicates a significant savings in fuel is possible by minor modifications in plant procedures.

This report also includes the results of an analysis of the quality of utility services supplied to the consumers on the site and an analysis of a series of environmental tests made for the effects of the plant on air quality and noise. In general, these analyses reflected favorable results for the total energy plant.

Economic and energy analyses are presented for the plant as operated during the period of the study and on a comparative basis with twelve alternative system designs applicable for providing the tenants on the site with equivalent utility services. In general, although those systems utilizing the total energy concept showed a significant savings in fuel, such systems do not represent attractive investments compared to conventional systems, with fuel costs of 1977.

**NBSIR 82-2475.** Moge, M. E. **Internal offsets and technological innovation: Six case studies.** 1982 April. 71 p. Available from: NTIS; PB 82-208372.

**Key words:** administrative experiment; air pollution; emissions trading; ETIP; innovation; offsets.

This report describes the experiences of six industrial firms with the new Federal policy of internal offsets. Offsets are part of a group of regulatory reforms initiated by the Environmental Protection Agency and called by the generic title of "emissions trading." Offsets were introduced to allow continued economic growth in nonattainment areas and to stimulate innovation in pollution control and process



technology by making it profitable for firms to create more reductions than the law now requires. The report discusses the problems of defining and measuring innovation as well as presenting industrial firm perceptions of innovation associated with offset cases.

**NBSIR 82-2477.** Kruger, J.; Hardman, V. K. **Current understanding of pitting and crevice corrosion and its application to test methods for determining the susceptibility to such corrosion of nuclear waste metallic containers.** 1982 April. 69 p. Available from: NTIS; PB 82-207507.

Key words: accelerated testing; crevice corrosion; electrochemical techniques; localized corrosion; localized corrosion mechanism; pitting.

Localized corrosion is the most damaging and prevalent type of corrosion that can affect metallic containers used in nuclear waste repository sites. Mechanisms of pitting and crevice corrosion and the techniques used in elucidating these mechanisms are discussed in this review which includes a literature survey.

**NBSIR 82-2478.** Swaffield, J. A. **Application of the method of characteristics to predict attenuation in unsteady partially filled pipe flow.** 1982 March. 89 p. Available from: NTIS; PB 82-196700.

Key words: building drainage; computer model; surge attenuation; unsteady flow.

The mechanism of flow attenuation in partially filled unsteady pipe flow is presented and shown to have relevance to the design of gravity drainage systems.

The equations defining unsteady flow in partially filled pipe are derived and shown to be capable of solution by means of the method of characteristics. This technique as a method of predicting flow depth, velocity and wave speed along a long drainage pipe at a range of pipe gradients, diameters, and roughness coefficients was tested by means of numerical examples for a series of simulations run on a digital computer. Additionally, limited experimental verification of the analysis technique is presented for the supercritical flow response to a short duration inflow surge.

Generally, the technique developed was found to be applicable to the design of drainage systems and further work is proposed to both extend the experimental verification and for the greater complexity of the multi-branched pipe system.

**NBSIR 82-2479.** Gevarter, W. B. **An overview of artificial intelligence and robotics. Volume II—Robotics.** 1982 March. 100 p. Available from: NTIS; PB 82-204439.

Key words: applications; forecast; Japan; overview; research and development; robot; state-of-the-art.

This report provides an overview of the rapidly changing field of robotics. It is intended to be read by the technically oriented layman, such as engineering managers, government funding offices, and others who desire an overall perspective of the field but are unable to obtain it from the highly technical and unintegrated literature in the field, or from the more flamboyant but non-technical feature articles in the popular press.

The report incorporates definitions of the various types of robots, a summary of the basic concepts utilized in each of the many technical areas, review of the state-of-the-art and statistics of robot manufacture and usage. Particular attention is paid to the status of robot development, the organizations involved, their activities, and their funding. A 5-10 year forecast of the emerging technology is also included.

The majority of the material in this report is drawn from the activities in the U.S. and Japan, the principal players in the world of robotics.

**NBSIR 82-2480.** Stahl, F. I.; Crosson, J. J.; Margulis, S. T. **Time-based capabilities of occupants to escape fires in public buildings: A review of code provisions and technical literature.** 1982 April. 168 p. Available from: NTIS; PB 82-212887.

Key words: emergency egress; fire protection; fire safety; human behavior in fires; human factors; Life Safety Code; means of egress.

This document reviews available technical literature pertaining to exit facility design and emergency escape provisions of the National Fire Protection Association's *Life Safety Code* (1976 Edition) in order to determine the technical support for such provisions. The report focuses on the time-based capabilities of building occupants to effect rapid evacuations, in relation to evacuation time available during fires. A number of functional criteria are examined in relation to *Code* provisions influencing the design of means of egress and fire protection and protective signalling systems for places of assembly, residential occupancies, mercantile occupancies, and business occupancies. Provisions affecting fire exit drill and building management practices are also considered. The technical literature bearing on applicable *Code* provisions is reviewed, the validity and generalizability of findings presented in the literature are discussed, and the degree of technical support currently available for egress provisions of the *Code* are evaluated. In addition, gaps in the technical literature are identified, and recommendations regarding future research are offered. Finally, preliminary conclusions about the supportability of *Code* provisions are presented.

**NBSIR 82-2482.** Smith M. K.; Hudson, D. R.; Boeing Computer Services Company. **A report on a survey of validation, verification, and testing standards and practices at selected sites.** 1982 April. 138 p. Available from: NTIS; PB 82-209172.

Key words: environment; software development and maintenance; software validation; standards; verification and testing; V,V&T technique and tools.

A survey of software validation, verification and testing (V,V&T) practices at five governmental and five commercial sites was performed. The survey collected information describing each site environment, software development and maintenance practices, the V,V&T techniques and tools employed, and standards and/or procedures guiding the activities at each site. This report summarizes the information obtained and presents observations about current operations with respect to software development, maintenance, and V,V&T. It also includes reports discussing each of the sites surveyed, and the survey instruments used.

**NBSIR 82-2483.** Hurley, C. W.; Ryan, J. D. **Performance analysis of the Jersey City total energy site: Executive summary.** 1982 March. 60 p. Available from: NTIS; PB 82-201401.

Key words: absorption chillers; boiler performance; diesel engine performance; engine-generator efficiency; integrated utility system; total energy systems-economic and engineering analysis; waste heat recovery.

Under the sponsorship of the Department of Housing and Urban Development (HUD), the National Bureau of Standards gathered engineering and economic data from an apartment/commercial complex located on a 6.35 acre (2.6 hectare) site in Jersey City, New Jersey.

The National Bureau of Standards was responsible for instrumenting the plant and site buildings and recording engineering data utilizing an automatic data acquisition system (DAS). The DAS was put on-line in April 1975.

Economic, reliability and environmental data were also collected and analyzed by NBS in conjunction with an analysis of the engineering data. This report presents an "Executive Summary" of the final report on the performance analysis of the Jersey City Total Energy Project. The reader is encouraged to refer to that final report for further details.

The analysis of the engineering data clearly indicates a significant savings in fuel by using the total energy concept in the plant. Several areas were also identified by this analysis where minor modifications in the plant operation could result in additional fuel savings. Three of the modifications have already been incorporated in the present plant operational procedures.

**NBSIR 82-2484.** Stone, W. C. **Internal strain, deformation, and failure of large scale pullout tests in concrete.** 1982 May. 170 p. Available from: NTIS; PB 82-229147.

Key words: concrete; crack propagation; failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; large scale models; mathematical model; pullout test; stress contours.



A study was performed to obtain detailed experimental data on crack propagation and internal strain distribution for the pullout test. A 12:1 scaled-up pullout test was designed, using a commercial pullout insert for the prototype dimensions, and was instrumented with small waterproof embedment strain gages so as to obtain internal strain profiles as critical locations. Two large scale specimens were tested with apex angles falling at the upper and lower bounds currently recommended in ASTM C-900. Two dimensional axisymmetric finite element analyses were performed for the two experimental specimens and the results were compared with measured strains for load stages below the onset of internal cracking. The results showed good correlation between the analytical and experimentally observed strains. The experimental data indicate that internal cracking, and the formation of the failure surface, are principally governed by the tensile strength of the concrete. The failure surface appears to have formed by 65% of ultimate load. Beyond this point, it is likely that the entire load is carried by the mechanism of aggregate interlock. Ultimate failure occurs when all aggregates mechanically bridging the failure surface pullout from the retaining cement paste. It is likely that the pullout test measures the shear strength of the cement paste or mortar which binds the concrete together.

**NBSIR 82-2486.** McKnight, R. H. The measurement of net space charge density using air filtration methods. 1982 April. 28 p. Available from: NTIS; PB 82-225723.

Key words: corona discharge; HEPA filters; ion counters; ion density; ions; net space charge.

The efficiency of a high efficiency particulate air (HEPA) or absolute filter for removing charge from an airstream has been measured for a variety of space charge and air flow conditions. Ion densities ranged from  $10^5$  to  $10^6/\text{cm}^3$  and were for positive and negative space charge as well as mixtures. For all conditions studied, the transmission of the filter was less than 0.1%. For space charge consisting predominantly of ions of one polarity, space charge density measurements made using HEPA filters and ion counters may be compared directly. The filter is well suited for all accurate measurements of net space charge density. Three other types of fibrous filters also have been studied.

**NBSIR 82-2487.** Jenkins, D. R.; Mathey, R. G. Hail impact testing procedure for solar collector covers. 1982 April. 86 p. Available from: NTIS; PB 83-104745.

Key words: hail damage; hail impact testing; hail launcher; simulated hail testing; solar collector covers; test method development.

This report presents laboratory test results which simulate hail impact on solar collector covers. The general objective of the work is to contribute to the development of a test method for evaluating the resistance of solar collector covers to this type of loading. A procedure for such testing is described as well as results obtained with ice balls impacting four typical collector cover materials. Aspects which are discussed include the preparation of ice balls, the design and operation of a launcher for ice ball propulsion, the method of mounting cover panel specimens, the selection of ice ball velocity and impact location, and techniques for failure or damage assessment.

The research results show that ice balls of consistent diameter and mass can be prepared in the laboratory. Further, both analysis and results tend to show that acceptable simulation for evaluation or testing can be achieved with normal impacts of ice balls traveling at a resultant velocity which is the vector sum of the terminal velocity and a horizontal wind component. Results for a variety of impact locations are presented and for comparison purposes, arbitrarily selected points near the collector cover boundaries appear to be a reasonable choice. Finally, it is shown that for some collector cover materials, more than one kind of failure must be considered when evaluating test results. Test data for two types of tempered glass, semirigid fiber reinforced plastic, and flexible thin plastic film covers are presented.

**NBSIR 82-2488.** Fang, J. B. Fire endurance tests of selected residential floor constructions. 1982 May. 113 p. Available from: NTIS; PB 82-225079.

Key words: fire endurance; fire tests; flame through; floors;

furnace tests; joists; steel; wood.

A series of 10 load-bearing, wood- and steel-framed residential floors was evaluated for structural fire resistance in a fire endurance furnace. Nine wood-frame and one light gauge steel-frame, protected and unprotected floor/ceiling assemblies, each measuring  $3.05 \times 2.44$  m in size, were exposed from the underside to either the newly developed high-intensity, short-duration fire exposure or the standard ASTM E 119 time-temperature curve. The fire endurance time based on the passage of flames to the unexposed face of the floor with unprotected wood joists varied from 6 to 9 minutes under the newly developed fire exposure and 16 to 18 minutes subject to the standard ASTM fire. Under the identical fire exposure, the exposed steel-framed floor failed in approximately 4.5 minutes compared to 9 minutes for the unprotected wood-frame floor. The wood floors evaluated in the test furnace had a shorter fire resistance period in comparison with those tested previously under room fire conditions probably due to faster charring rates and additional heat contribution from the burning of combustible materials in the structure with the excess air present in the furnace.

**NBSIR 82-2490.** Clark, D. B.; Weeks, S. J.; Hsu, S. M. An introduction to chemiluminescence methods for lubricant oxidation studies. 1982 April. 37 p. Available from: NTIS; PB 82-207515.

Key words: additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review.

An introductory review of chemiluminescence (CL) techniques describes applications for the study of oxidation of fuels and lubricants. Reviews of chemiluminescence and oxidation are briefly discussed. The mechanism of CL as it applies to complex hydrocarbon systems is discussed. Several steady state and nonsteady state kinetic methods are discussed with respect to the ability of each technique to give useful information about the kinetics and mechanisms of oxidation. Applications of CL techniques for fuels and lubricants, as well as simple hydrocarbon systems, are discussed.

The unique properties of CL methods for materials testing (e.g., lubricant oxidation stability) as well as fundamental understanding of chemical oxidation reactions are emphasized. Studies which evaluate petroleum and synthoil products, oxidation inhibitors and metal catalysts are discussed. Instrumentation capabilities are reviewed and critical features of instrumental design are discussed.

**NBSIR 82-2491.** Kirklin, D. R.; Colbert, J. C.; Churney, K. L.; Reilly, M. L.; Thornton, D. D.; Ryan, R. V.; Ledford, A. E.; Domalski, E. S. Test procedures for the determination of the gross calorific value of refuse and refuse-derived-fuel of kilogram-size samples using constant pressure flow calorimetry. Summary of the 1980 Fiscal Year results. 1982 June. 88 p. Available from: NTIS; PB 82-238338.

Key words: calorific value; flow calorimetry; kilogram-size samples; municipal solid waste; refuse-derived fuel; sample characterization; sample variability.

This report describes the systematic approach used at the National Bureau of Standards to design, construct, and place into operation a constant pressure flow calorimeter which can accommodate kilogram-size samples. The contents of the report are divided into three parts: Part A—The Variability of Municipal Solid Waste and its Relationship to the Determination of the Calorific Value of Refuse-Derived Fuels; Part B—25 Gram Capacity Combustion Flow Calorimeter; and Part C—Trial Combustions of Kilogram-Size Samples of Municipal Solid Waste.

The primary objective of this effort is to develop a procedure for the determination of accurate calorific values for minimally processed MSW and to correlate these calorific values with those obtained on RDF samples which have been processed to a small particle size.

**NBSIR 82-2492.** Mattis, R. L.; Till, L. J.; Frisch, R. C. A computer program for analysis of data from microelectronic test structures. 1982 June. 38 p. Available from: NTIS; PB 82-252347.

Key words: computer program; correlation coefficient; outlier; process validation wafer; statistical analysis; two-dimensional arrays; wafer map.

A computer program, STAT2, is described which performs the



following functions: reads data as a two-dimensional array; calculates mean, sample standard deviation, and median; identifies outliers; calculates replacement values for outliers; makes a gray-tone data map on a line printer; makes a character map on the user's terminal; constructs a data base for examining correlations among various data sets; and searches the data base for correlations using several selective keys. The emphasis in this document is on program usage, and detailed descriptions of the commands are given. Program portability and data input requirements are addressed. Guidance regarding several types of program modifications is provided.

**NBSIR 82-2493.** Crissman, J. M.; Khoury, F. A.; McKenna, G. B. NBS-BMD Interagency Agreement, task 80-01. Second annual report "Relationship between morphology and mechanical properties of UHMWPE". 1982 May. 60 p. Available from: NTIS; PB 82-211426.

Key words: creep; fatigue; morphology; polyethylene; stress-crack resistance; stress-relaxation; ultra high molecular weight.

This report describes work done during FY 1981 under task 80-01, NBS-FDA/BMD (Bureau of Medical Devices) Interagency Agreement. The report covers the second year of a four year project concerned with the relationship between morphology and mechanical properties of ultra high molecular weight polyethylene (UHMWPE). Various aspects of the UHMWPE being investigated include (1) the establishment of procedures for compression molding (under vacuum) sheets and cylinders of the polymer, (2) the influence of thermal history and molecular weight on the time dependent mechanical behavior such as creep and stress relaxation in both uniaxial extension and compression, (3) dynamic fatigue under conditions of zero-tension sinusoidal loading, (4) environmental stress-crack resistance, and (5) the optical and electron microscopy of sheets of the UHMWPE which have been deformed to varying degrees in uniaxial extension.

**NBSIR 82-2496.** Jones, F. E. Determination of water in plutonium dioxide. 1982 April. 5 p. Available from: NTIS; PB 83-126631.

Key words: automatic titration; Karl Fischer reagent titration; moisture; nuclear safeguards; plutonium dioxide; water determination.

Techniques developed to very effectively apply automatic Karl Fischer reagent titration to the determination of  $H_2O$  in solids were used to determine the moisture content of samples of plutonium dioxide powder under the constraints imposed by the necessity of working in a glove box. The moisture contents of three samples were found to be 0.2934%, 0.7298%, and 0.4640%. The estimate of the relative standard deviation of the mean for three determinations on the 0.2934%  $H_2O$  sample was 0.0091. The method apparently has potential as the basic reference method for determination of  $H_2O$  in plutonium dioxide, as a means of standardizing other methods, and as a diagnostic tool.

**NBSIR 82-2497.** Kweller, E.; Palla, R. A test method and calculation procedure for determining annual efficiency for vented household heaters and furnaces equipped with modulating type thermostat controls. 1982 May. 65 p. Available from: NTIS; PB 83-137166.

Key words: annual efficiency; household heaters and furnace test procedures; hydraulic thermostat control; modulating control gas-fueled; two-stage thermostat.

As annual operating efficiency of vented heating equipment is affected by burner fuel and combustion air modulation, it is important to differentiate between the various types of controls in determining annual energy requirements. Test procedures for evaluating annual efficiency have already been developed and implemented by the Department of Energy (DoE) for furnaces with single-stage thermostat control. A modified test procedure is necessary to account for operation with fuel modulation. A revised procedure which accommodates two types of fuel modulating controls has recently been developed. Tests are conducted at reduced and maximum firing rates, and along with typical derived values from a bin analysis of weather data, the fraction of the total hours for each operating mode is obtained to calculate a weighted annual efficiency. These test methods and calculation procedures are based on and are an extension to the current DoE test procedures for the single-state type of thermostat control of central warm air furnaces.

By using the procedures developed in the report, the energy savings impact of fuel modulating controls when combined with the

use of modulated combustion air is evaluated. Energy savings from 6 percent to 20 percent were determined from the increase in efficiency with both fuel and combustion air modulation. Improved efficiency was dependent on the type of thermostat control and the minimum-to-maximum fuel input; i.e., turndown ratio.

**NBSIR 82-2498.** Ruberg, K. Solar availability in cities and towns: A computer model. 1982 March. 236 p. Available from: NTIS; PB 82-202201.

Key words: daylighting; glazing transmission; shading algorithms; solar access; solar radiation data; urban solar application.

An interactive computer program, SOLITE, has been written to determine the incident solar radiation on urban building surfaces, street surfaces and rooms facing urban street canyons. Hourly weather data and surface descriptors are interactively entered by the user. Solar radiation data are calculated with NOAA weather tape (TMY or TRY) cloud data using the Kimura/Stephenson cloud cover algorithm. SOLITE also calculates solar radiation transmission through user specified glazing assemblies. Shadows cast by surrounding buildings and overhangs are computed, as are the interreflection effects in street canyons. In addition, internal heat gains from occupants and lighting, and daylight availability on the workplane of a room are calculated. Output options include weather data summaries, incident insolation, occupant heat gain in rooms and useable hours of daylight in a room with a given occupancy. Either hourly or daily values may be specified as output.

**NBSIR 82-2499.** Jason, N. H. Fire research publications, 1981. 1982 April. 16 p. Available from: NTIS; PB 82-220104.

Key words: bibliographies; building fires; coal mines; combustion products; compartment fires; fabric flammability; fire research; fire tests; flame research; smoke.

"Fire Research Publications, 1981" is a supplement to the previous editions: 1969-72 NBSIR 73-246, NTIS Order No. COM-74-10989; 1973 NBSIR 74-511, NTIS Order No. COM-74-11448; 1974 NBSIR 75-736, NTIS Order No. COM-75-11018; 1975 NBSIR 76-1120, NTIS Order No. PB-257837; 1976 NBSIR 77-1277, NTIS Order No. PB-269965; 1977 NBSIR 78-1504, NTIS Order No. PB-284462; 1978 NBSIR 79-1745, NTIS Order No. PB-295395; 1979 NBSIR 80-2114, NTIS Order No. PB80-103335; 1980 NBSIR 81-2272, NTIS Order No. PB81-203317.

Only publications prepared by members of the Center for Fire Research (CFR), by other National Bureau of Standards (NBS) personnel for CFR, or by external laboratories under contract or grant from the CFR are cited. Articles relating to fire safety published in NBS house organs also are cited.

**NBSIR 82-2500.** Blessing, G. V. Ultrasonic measurements of titanium 6211 weld and plate. 1982 May. 15 p. Available from: NTIS; PB 82-221672.

Key words: nondestructive evaluation; titanium plate; titanium welds; ultrasonic C-scan; ultrasonic velocity; weld porosity.

Ultrasonic shear and longitudinal waves are used to evaluate the elasticity and attenuation of titanium weld and plate alloy. Wave speeds are used to measure the materials' elasticity and anisotropy, and the wave amplitude is used to measure relative levels of scattering in the weld and plate regions. Results obtained on a representative weld are compared with results obtained on oxygen contaminated specimens.

**NBSIR 82-2501.** Hebner, R. E., ed. Development of power system measurements—Quarterly report October 1, 1981 to December 31, 1981. 1982 May. 21 p. Available from: NTIS; PB 82-227075.

Key words: cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil.

This report documents the progress on four technical investigations sponsored by the Department of Energy and performed by the Electrosystems Division, the National Bureau of Standards. The work described covers the period October 1, 1981 to December 31, 1981. The report emphasized measurements of ion density in air, the use of



signals above 1 GHz to detect incipient faults in cables, the measurement of the by-products which develop during partial discharge activity in SF<sub>6</sub>, and the determination of the breakdown behavior of an oil-paper interface.

**NBSIR 82-2503.** Lawson, J. R.; Parker, W. J. Development of an ease of ignition test using a flame exposure. 1982 July. 64 p. Available from: NTIS; PB 82-252339.

Key words: building materials; fire tests; flame attachment; heat flux; ignition; room fires; wall coverings.

A test for the ease of ignition of interior finish materials by flame exposure was developed. Two specimens, 140 mm (5.5 in) wide by 152 mm (6 in) high, face each other at a distance of 53 mm (2.1 in) apart. A methane diffusion flame passes between their surfaces and extends to about 152 mm (6 in) above them. The operator observes the specimen surface and records the time-to-flame attachment. A phototube, which views the exposure flame, shows a marked increase in output when the specimens start contributing fuel. The times-to-flame attachment were compared with the observed times of wall involvement in some full-scale tests. The ignition sensitivity is expressed by the time-to-flame attachment and by the time-to-fuel contribution. The times-to-flame attachment measured in the ignition apparatus generally ranked 22 materials with the observed times of wall involvement in full-scale tests. The results of this test may be useful as one factor in computer models of fire growth in enclosures.

**NBSIR 82-2504.** Chuang, T. J.; Fuller, E. R., Jr.; Fields, R. J.; Chuck, L. Effects of crack growth on the load-displacement characteristics of precracked specimens under bending. 1982 May. 41 p. Available from: NTIS; PB 82-237678.

Key words: ceramic fracture test; crack growth of ceramics; four-point bend test; fracture test; initial value problem; load-displacement characteristics; power-law crack growth.

A critical evaluation of the feasibility of obtaining crack growth parameters from bend tests is presented. First derived are the governing differential equations which characterize the time-history of bend test parameters for a given elastic material exhibiting power law crack growth behavior. A numerical solution scheme is then developed which is capable of solving the initial value problem, thus quantitatively assessing the influence of crack growth on the load-displacement output. The results of this analysis indicate that for high N materials (where N is the exponent in the power law crack growth equation) the flexural test method gives a broad error band in N prediction and hence is not a reliable technique. However, it can be used by a designer to quickly screen the new materials with high N values which are potential candidates for structural application.

**NBSIR 82-2505.** Gevarter, W. B. An overview of expert systems. 1982 May. 73 p. Available from: NTIS; PB 82-227539.

Key words: applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; research; state-of-the-art.

This report provides an overview of Expert Systems—currently the hottest topic in the field of Artificial Intelligence. Topics covered include what it is, techniques used, existing systems, applications, who is doing it, who is funding it, the state-of-the-art, research requirements, and future trends and opportunities.

**NBSIR 82-2506.** Loftus, J. J. Evaluation of wall protection systems for wood heating appliances. 1982 May. 61 p. Available from: NTIS; PB 82-215088.

Key words: chimneys; fire tests; flues; heating equipment; literature reviews; radiant energy; stoves; wall protection; walls; wood.

Measurements of the surface heating potential of unprotected and protected gypsum wallboard materials in close proximity to irradiating surfaces of home heating appliances have been made. A total of 4 unprotected walls and 19 protected interior wall surfaces were evaluated in tests where stove-to-wall clearances were varied from 7.5 to 90 cm (3 to 36 in) and stove surface temperatures were maintained at five different temperature levels ranging from

150–350°C (300–660°F).

The systems found most effective in offering thermal protection to the base wall surface (i.e., gypsum wallboard) were those consisting of a metal plate surface offset by an air space in front of the wallboard material.

Unprotected gypsum wallboard surfaces were ignited when the stove to wall clearance was 7.5 cm (3 in) and the stove surface measured 350°C (660°F).

**NBSIR 82-2507.** Klote, J. H. Elevators as a means of fire escape. 1982 May. 39 p. Available from: NTIS; PB 82-230269.

Key words: building fires; egress; elevators (lifts); evacuation; handicapped; pressurization; smoke control; stairwells.

This paper is the initial report of an ongoing project at NBS to investigate the use of elevators as a means of fire escape for the handicapped. The use of stairwells for fire evacuation poses a problem for people who cannot use stairs because of physical disabilities. This paper discusses some of the major problems associated with the use of elevators as a means of fire exit and proposes a conceptual solution to those problems. A report is made on field tests of four buildings with elevator protection systems. These protection systems and their interactions with other systems are examined.

**NBSIR 82-2508.** Quintiere, J. G. An assessment of correlations between laboratory and full-scale experiments for the FAA Aircraft Fire Safety Program, Part 1: Smoke. 1982 July. 53 p. Available from: NTIS; PB 83-113522.

Key words: correlation; fire tests; full-scale; smoke; smoke density chamber; optical density; test methods; visibility.

An extensive review is presented demonstrating the nature of comparison between full-scale fire smoke data and test method results for materials. These correlations are presented in terms of consistent parameters established through a development of the governing equations for smoke concentration and light attenuation. Visibility data pertaining to light transmission through smoke is presented but no general results exist on the sensory irritant effect of smoke on vision. Analysis shows the complex dependence of smoke production on many parameters acting in fire growth and shows the futility and nature of simple correlation attempts. Recommendations are made for further research to establish a sounder basis for correlations, and a practice strategy is suggested for proceeding in the present.

**NBSIR 82-2509.** Fink, J. L.; Escalante, E.; Gerhold, W. F. Corrosion evaluation of underground telephone cable shielding materials. 1982 June. 88 p. Available from: NTIS; PB 82-245838.

Key words: alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground.

Corrosion data are given on the performance of base and plastic-coated metals intended for use as cable shields for buried telephone cable. The materials investigated on specially prepared specimens were buried for periods up to six years in six different soil environments. Metals tested included homogeneous plastic-bonded and metallurgically-bonded laminates. Some specimens were exposed bare (uncoated), while others had plastic coatings or other types of coatings on either one or both sides. Metals studied included aluminum, copper, low carbon steel, and stainless steel alloys.

**NBSIR 82-2514.** Suehle, J. S.; Linholm, L. W.; Marshall, G. M. Evaluation of a CMOS/SOS process using process validation wafers. 1982 June. 67 p. Available from: NTIS; PB 82-237652.

Key words: integrated circuits; microelectronics; process control; process validation wafer; silicon on sapphire; test chip; test pattern; test structure; yield.

The objective of this work was to determine baseline electrical parameters that could be used to evaluate a fabrication process. Two lots of wafers containing NBS-16 test chips were fabricated at a commercial vendor in a radiation-hard, CMOS/SOS process. These wafers were then returned to NBS for testing and evaluation. Testing was performed using an automated computer-controlled integrated circuit test system. Test results were evaluated using analysis techniques which provided a statistical estimate of selected parameters and identified spatial correlations between data sets.



Further analysis was then performed in order to identify process irregularities. A complete description of the test results and analysis procedure can be found in the appendices.

**NBSIR 82-2517.** McKnight, R. H.; Kotter, F. R. **A facility to produce uniform space charge for evaluating ion measuring instruments.** 1982 June. 32 p. Available from: NTIS; PB 82-238353.

Key words: electrostatic potential; high efficiency air particulate (HEPA) filters; ion counters; ion density; measurement; net space charge.

A low-speed wind tunnel containing space charge has been constructed and evaluated. The facility is used for testing the performance of ion counters and net space charge measuring devices. Depending on location within the system, space charge densities range from  $2-7 \times 10^{-8}$  C/m<sup>3</sup>. The space charge density is spatially uniform within  $\pm 5\%$  over more than 90% of the cross sectional area of the test volume, but decreases by approximately 20% between two positions separated by 1 m. Ion densities achieved in this system are comparable to those found near high voltage dc transmission lines but are free from the accompanying large electric fields.

**NBSIR 82-2519.** Gomberg, A.; Clark, L. P. **Rural and non-rural civilian residential fire fatalities in twelve states.** 1982 June. 52 p. Available from: NTIS; PB 82-252032.

Key words: fire cause; fire data; fire fatalities; fire statistics; heating equipment; residential fires; rural fires.

The results of an analysis of fire causal factors in over 1600 fire fatalities are presented. The primary emphasis is on the identification of fire causes leading to demonstrated high fatality rates in rural areas. It was found that the most significant rural fire fatality cause was heating equipment, with improper installation and misuse of solid fueled heating equipment predominating. Other fire causes making significant contributions to high rural fatality rates were also investigated and documented. Additional data are currently being collected to enable further evaluation of rural fire problems.

**NBSIR 82-2520.** Steckler, K. D.; Quintiere, J. G.; Rinkinen, W. J. **Flow induced by fire in a compartment.** 1982 July. 101 p. Available from: NTIS; PB 83-107714.

Key words: air flows; compartment fires; entrainment; fire plumes; flow rates; opening flows.

Fifty-five full-scale steady-state experiments were conducted to study the flow induced by a simulated pool fire in a compartment under conditions characteristic of the developing fire. The mass flow rate through the door or window opening and bounds on the fire plume entrainment rate are presented as a function of opening geometry, fire strength, and fire location.

The characteristics of the measured opening flow rates are explained by a simple hydrostatic model based on temperature distribution. A good correlation between the measured results and the idealized flows, taking into account the complete temperature distribution, is demonstrated.

Entrainment results for fires near walls are in reasonable agreement with results from free-standing plume models. Except for the smallest openings, fires in other locations entrain at a rate two to three times the rate predicted by these models. This phenomenon is attributed to room disturbances caused by the opening flow and is similar to the behavior of a fire plume in a cross wind.

**NBSIR 82-2521.** Hayes, W. D., Jr.; Zile, R. H. **Full-scale study of the effect of pendent and sidewall location on the activation time of an automatic sprinkler.** 1982 July. 74 p. Available from: NTIS; PB 82-251125.

Key words: automatic sprinklers; compartment fires; fire safety; life safety; room fires; sidewall sprinkler systems; thermal response.

A series of 17 full-scale tests was conducted to obtain measurements of the thermal response behavior of simulated and actual sprinklers positioned in the pendent and two separate sidewall locations. Exposure fires were simulated by a propane burner, and replicated the approximate temperature rises of several different burning furniture items typically found in residential and board-and-care type

occupancies.

The results indicate that for this test arrangement the response time of a sprinkler is influenced by the location of the sprinkler, the growth rate of the fire, and the response characteristics of the sprinkler itself. In addition, for the fire growth rates studied, differences between the activation times of a pendent positioned sprinkler and those of two sidewall locations appeared significant. In some cases, it appears that equivalent response time at the sidewall location to that of a pendent location cannot be achieved for the configurations tested. The implications of these results require further investigation.

**NBSIR 82-2522.** Jenkins, J. P.; Reed, K. A. **A comparison of unglazed flat plate liquid solar collector thermal performance using the ASHRAE Standard 96-1980 and modified BSE test procedures.** 1982 May. 34 p. Available from: NTIS; PB 82-237660.

Key words: ASHRAE Standard 96-1980; BSE; collector efficiency; unglazed collector.

This paper reviews the BSE procedure and summarizes the ASHRAE Standard 96-1980 for testing unglazed solar collectors. The ASHRAE procedure consists exclusively of outdoor testing, whereas the BSE procedure requires a combination of outdoor and indoor testing (no irradiation) to determine the collector optical and thermal loss characteristics, respectively. Two unglazed flat plate liquid solar collectors were tested according to ASHRAE Standard 96-1980 and BSE procedures and the results compared. During the indoor BSE thermal loss tests blowers were used to simulate winds of 0-3.9 m/s (0-8.72 mi/hr) to investigate the wind effect upon collector thermal losses. The results demonstrate that the differences between the BSE and ASHRAE Standard 96-1980 thermal efficiency curves were less than the uncertainty associated with the curves.

**NBSIR 82-2523.** Bryson, J. O.; Thomas, D.; Drake, L.; Hall, W. A. **Bibliography on laboratory accreditation.** 1982 June. 107 p. Available from: NTIS; PB 82-237694.

Key words: acceptance testing; accreditation systems; history; International Laboratory Accreditation Conference; international testing; laboratory accreditation.

This bibliography was prepared by staff members of the U.S. National Bureau of Standards at the request of and in cooperation with the International Laboratory Accreditation Conference (ILAC). The purpose of this work is to promote and accommodate the exchange of world wide information concerning laboratory accreditation and related subjects.

**NBSIR 82-2524.** Wiederhorn, S. M.; Freiman, S. W.; Fuller, E. R., Jr.; Simmons, C. J. **Effects of water and other dielectrics on crack growth.** 1982 June. 60 p. Available from: NTIS; PB 82-235896.

Key words: cracks; fracture; glass; static fatigue; strength; subcritical crack growth.

The effect of water and a variety of organic liquids on the crack growth rate in soda lime silica glass was investigated. When water is present in organic liquids, it is usually the principal agent that promotes subcritical crack growth in glass. In region I, subcritical crack growth is controlled primarily by the chemical potential of the water in the liquid; whereas in region II, crack growth is controlled by the concentration of water and the viscosity of the solution formed by the water and the organic liquid. In region III, where water does not affect crack growth, the slope of the crack growth curves can be correlated with the dielectric constant of the liquid. It is suggested that these latter results can be explained by electrostatic interactions between the environment and charges that form during the rupture of Si-O bonds.

**NBSIR 82-2525.** Quintiere, J. G. **An assessment of correlations between laboratory and full-scale experiments for the FAA Aircraft Fire Safety Program, Part 4: Flammability tests.** 1982 July. 27 p. Available from: NTIS; PB 83-113548.

Key words: compartment fires; correlations; corridor tests; fire growth; fire tests; flammability; flashover; interior finishes; room fires.



A review is made of studies in which full-scale fire growth was compared with laboratory test data on materials. Both room and corridor fires are included in which primarily interior lining materials have been the combustible element. The studies include standard test methods and other laboratory devices used in the United States and other countries. An effort was made to intercompare experimental results in a common basis. For example, maximum room temperature data are compared with ASTM E-84 flame spread classifications for several full-scale tests which involved nearly the same room geometries and same fuel arrangements.

**NBSIR 82-2527.** McKnight, R. H.; Kotter, F. R.; Misakian, M.; Hagler, J. N. 1981 Annual Report: Electric and magnetic field measurements. 1982 July. 48 p. Available from: NTIS; PB 82-263377.

Key words: current density measurements; high efficiency particulate air filter; high voltage dc transmission lines; ion counter; ion density; net space charge density.

The NBS program is concerned with developing methods for evaluating and calibrating instrumentation for use in measuring the electric field and various ion-related electrical quantities in the vicinity of high voltage direct current (HVDC) transmission lines and in apparatus designed to simulate the transmission line environment.

The laboratory investigation of errors associated with above-ground operation of sensors for measuring vertical current density has been completed. Significant errors were observed for both unguarded and guarded sensors, ranging from 4 to 25% for the guarded plates and 10 to 35% for unguarded plates for a wide range of geometrical parameters. Preliminary results from a field day held in October 1981 are in agreement with the laboratory results.

A new low-speed air-flow facility has been constructed. Using multiwire planar corona discharge ion sources, ion densities from  $1.6 \times 10^5/\text{cm}^3$  to  $1.4 \times 10^6/\text{cm}^3$  have been measured using an absolute filter technique.

Losses at the inlet of a parallel plate ion counter due to fringing fields have been determined using an ion counter with variable geometry. Calculations based on a two-dimensional finite element code predict a greater loss than actually observed, but are in qualitative agreement with experimental results.

The above-ground operation of a parallel plate has been investigated using a monopolar line. The initial results obtained show that the ion densities measured using the counter are strongly dependent on ion counter potential. These results represent only a limited set of measurements, but indicate problems associated with above-ground measurements of ion density.

The transmission of charge in an air stream through a high efficiency particulate air (HEPA) filter has been determined to be less than 0.1% for a wide range of flow and ion density conditions. This result indicates that a HEPA filter may be useful in calibrating ion counters when the net space charge density and ion density are equivalent.

A retarding field scheme has been considered for use in measuring the mobility spectrum of the ions in the low-speed air flow facility. The results of a limited number of measurements show that the method may be a useful one for this application but that a number of problems need further investigation, including the effects of space charge.

**NBSIR 82-2528.** Hebner, R. E., ed. Development of power system measurements—Quarterly report January 1, 1982 to March 31, 1982. 1982 June. 20 p. Available from: NTIS; PB 82-229352.

Key words: cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil.

This report documents the progress on four technical investigations sponsored by the Department of Energy and performed by the Electrosystems Division, the National Bureau of Standards. The work described covers the period from January 1, 1982 to March 31, 1982. The report emphasizes the calibration of instruments designed to measure the 60-Hz electric field in biological exposure facilities, selected errors inherent in the use of time-domain reflectometry to determine the rf characteristics of power cables, the measurement of the rate of decomposition of SF<sub>6</sub> in positive dc-corona discharges, and in the measurement of space charge in transformer oil between 100°C and 150°C.

**NBSIR 82-2529.** Greenspan, M.; Eitzen, D. G. Ultrasonic research—Summary report and literature guide to the National Bureau of Standards/Office of Naval Research Program. 1982 June. 11 p. Available from: NTIS; PB 82-229345.

Key words: bibliography; physical acoustics; summary; ultrasonics.

This brief report summarizes research efforts in physical acoustics at the National Bureau of Standards (NBS) which were partially supported by the Office of Naval Research (ONR). It summarizes what we think are many of the major accomplishments at NBS in the area of physical acoustics from 1948 to 1981. The published literature documenting these successes is listed.

**NBSIR 82-2531.** Ings, J. B.; Brown, P. W. An evaluation of hydrated calcium aluminate compounds as energy storage media. 1982 July. 15 p. Available from: NTIS; PB 82-249921.

Key words: calcium-aluminum hydrates; calorimetry; dehydration; energy storage; rehydration; solar.

Calcium aluminate hydrates and calcium aluminate hydrates containing other ions were investigated to determine the feasibility of their utilization as energy storage media. A series of these compounds were fabricated and analyzed for purity. The energy liberated on hydration of each compound was measured using conduction calorimetry and the dehydration temperature was measured using differential scanning calorimetry. Of the compounds investigated, 3CaO·Al<sub>2</sub>O<sub>3</sub>·3CaSO<sub>4</sub>·32H<sub>2</sub>O liberated the largest amount of energy upon rehydration. Initially, this value was about 100 cal/gram. However, after 18 cycles of hydration and dehydration this value drops to about 70 cal/gram.

**NBSIR 82-2532.** Levin, B. C.; Fowell, A. J.; Birky, M. M.; Paabo, M.; Stolte, A.; Malek, D. Further development of a test method for the assessment of the acute inhalation toxicity of combustion products. 1982 June. 143 p. Available from: NTIS; PB 82-217886.

Key words: combustion products; flaming combustion; inhalation; materials; nonflaming combustion; test method; toxicity.

This report describes the development of a test method for the assessment of acute inhalation toxicity of combustion products of materials. The procedure is primarily intended for research and screening purposes. It provides: 1) a method for determining, under flaming and non-flaming conditions, the LC<sub>50</sub> (the concentration of combustion products which causes 50% lethality in the test animals (rats) exposed for 30 minutes and observed for 14 days following exposure); 2) an optional procedure to examine materials which rapidly produce combustion products which cause death of test animals within a 10 minute exposure and a 14 day post-exposure observation period; and 3) a description of analytical and physiological measurements which can provide more detailed information on the nature of the toxic effects of combustion products. Limitations of the test method are identified and future work to address them is proposed.

The participation through the direct exchange of technical information of organizations representing academia, industry, and other agencies of the United States Government is acknowledged.

**NBSIR 82-2533.** Clark, E. J.; Kelly, C. D.; Roberts, W. E. Solar energy systems—Standards for screening plastic containment materials. 1982 June. 52 p. Available from: NTIS; PB 82-242454.

Key words: durability; plastic containment materials; solar energy systems; standards.

Plastic materials are being chosen more frequently for various applications in solar energy systems. Problems with materials in solar systems have indicated a need for standards to assess the performance and durability of the materials. In this investigation laboratory studies have been performed to obtain data needed to develop standards to screen plastic containment materials for the effects of heat and for compatibility with heat transfer fluids. Five absorbers, three plastic pipe materials, and three plastics used in storage applications were included. They were evaluated to assess their durability after



exposure to heat aging at 100°C and 125°C and to chemical compatibility with six heat transfer fluids at room temperature and at 70°C.

The results of the laboratory tests are presented and a draft standard to screen plastic containment materials is proposed.

**NBSIR 82-2535.** Seiler, J. F.; McKnight, M. E.; Masters, L. W. **Development of a test apparatus and method for measuring adhesion of protective coatings.** 1982 July. 36 p. Available from: NTIS; PB 82-250010.

**Key words:** adhesion; measurement; protective coatings; test apparatus; test method.

A pneumatic test apparatus and associated test method for measuring the adhesion of coatings have been developed with particular emphasis on: 1) overcoming some of the shortcomings of existing tests; and 2) providing a method which can provide quantitative information for both laboratory and field applications.

The test apparatus utilizes compressed air to lift a stainless steel loading fixture (button) which is bonded with an adhesive to the surface of the protective coating. The rate at which the loading fixture is loaded is controlled by a precision air pressure gauge and the tensile force required to lift the button from one coating is measured. Assuming the level of adhesion of the adhesive to the coating is greater than that of the coating to the substrate, the tensile force provides a measure of the coating adhesion. Laboratory studies with two coating materials have been performed to assess the method.

This report describes the test apparatus and associated test method and presents test data obtained to date, proposed modifications to the initial test apparatus design, and additional research needs. An Instruction Manual for use of the test apparatus is included in the Appendix.

**NBSIR 82-2536.** Quintiere, J. G. **An assessment of correlations between laboratory and full-scale experiments for the FAA Aircraft Fire Safety Program, Part 2: Rate of energy release in fire.** 1982 July. 24 p. Available from: NTIS; PB 83-113530.

**Key words:** calorimeters; correlation; energy transfer; fire tests; flame spread; ignition; mass loss; test methods.

The rate of energy release in fire is discussed. The significance of calorimetric measurements of energy release for materials is related to thermal-dynamic parameters, namely heat of reaction and stoichiometric coefficients. It is shown that a common set of parameters is necessary to express ignition, flame spread and mass loss due to combustion and heat transfer in fires. The relationship of ignition and flame spread to rate of energy release in fires is presented along with a presentation on upward spread.

**NBSIR 82-2537.** Quintiere, J. G.; Tanaka, T. **An assessment of correlations between laboratory and full-scale experiments for the FAA Aircraft Fire Safety Program, Part 5: Some analyses of the post crash fire scenario.** 1982 July. 25 p. Available from: NTIS; PB 83-113555.

**Key words:** aircraft compartments; aircraft fires; flow rates; mathematical models; wind effects.

An attempt is made to develop mathematical predictions for various aspects of the dynamics of post-crash aircraft fires. The basis of the analysis is the experimental simulation scenario under study by the FAA. The effects of wind are considered as well as the effect of interior and exterior fires. Suggestions are presented for estimating cabin door flow rates from measured temperatures.

**NBSIR 82-2538.** Rennex, B. G. **Low-density thermal insulation calibrated transfer samples—A description and a discussion of the material variability.** 1982 June. 10 p. Available from: NTIS; PB 82-238346.

**Key words:** building insulation; energy conservation; guarded hot plate; heat flow meter; heat transfer; low-density mineral fiber; thermal conductivity; thermal resistance; thickness effect.

The National Bureau of Standards (NBS) has developed the capability to provide thick, low-density thermal insulation calibrated transfer samples to the thermal testing community. Previous research had indicated the need to measure thermal resistance of low-density

insulation samples at thicknesses up to 150 mm (6 in.). This is due to the "thickness effect," i.e., it is not possible to determine thermal resistance values at larger thicknesses based on tests at smaller thicknesses, such as at 25 mm (1 in.). There was controversy as to the magnitude of the "thickness effect." This involved the manufacturers of insulation, the United States Federal Trade Commission, and thermal test laboratories. Another factor is that the systematic errors of apparatuses which measure thermal resistance increase significantly at greater test thickness. In order to ensure better consistency among the thermal resistance apparatuses, NBS agreed to develop and provide calibrated transfer samples at thicknesses up to 150 mm (6 in.).

The calibrated transfer samples are described. The considerations that went into the selection and preparation of these low-density mineral-fiber samples are discussed. The contributions to the calibration uncertainty due to material variability are discussed and estimated to range between 1 percent and 2.5 percent.

**NBSIR 82-2539.** Margulis, S. T.; Clark, R. E. **Nontechnical summary of the final report "Optimal weatherization of low-income housing in the United States: A research demonstration project".** 1982 August. 43 p. Available from: NTIS; PB 82-260811.

**Key words:** Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization.

This report summarizes in nontechnical language the nature and results of the Community Service Administration's (CSA's) Optimal Weatherization Demonstration Research Project carried out by the National Bureau of Standards (NBS). This summary draws on the final report of the field evaluation of the Demonstration, an NBS publication entitled *Optimal Weatherization of Low-Income Housing in the U.S.: A Research Demonstration Project* (NBS BSS 144). Unless stated otherwise, this report references the final report.

The CSA/NBS demonstration installed both architectural (Building shell) and mechanical systems weatherization options, and achieved, when both types of options were used, an average reduction in space heating fuel consumption of 41 percent, at an average weatherization cost of \$1862 per house.

This summary report also includes abstracts of all the technical reports documenting the CSA/NBS project. Directions for ordering available reports are included.

**NBSIR 82-2540.** Ruegg, R. T.; Sav, G. T.; Powell, J. W.; Pierce, E. T. **Economic evaluation of solar energy systems in commercial buildings: Methodology and case studies.** 1982 July. 205 p. Available from: NTIS; PB 82-260456.

**Key words:** building economics; commercial buildings; economic analysis; energy economics; life-cycle costing; solar energy.

This report develops a comprehensive economic optimization model for evaluating the economic feasibility of active solar energy systems to provide service hot water and combined space heating/service hot water in commercial buildings. The model is demonstrated in a number of case studies for office buildings and retail stores. Data and assumptions for use in the model are compiled for the selected case studies. Using these data, the model is applied to estimate present value net savings (or net losses) of the solar energy systems over a 20-year life cycle. Break-even values for hot water loads, solar energy system costs, and current and future energy prices are also calculated to determine the minimum conditions under which the solar energy systems become cost effective for the selected buildings. Economic optimization paths which show the optimal solar collector areas and the corresponding present value of net savings (or net losses) associated with a range of hot water loads are developed in the case studies. Sensitivity analysis is conducted for key variables. The relationship between total life-cycle costs and the solar fraction is tested for selected cities to demonstrate how net savings (net losses) change as the solar fraction is increased. In its approach, this report is of interest to solar analysts; in its results, to the solar policy, research, and building communities.

**NBSIR 82-2541.** Cushman, R.; Deprit, A.; Mosak, R. **Normal form and representation theory.** 1982 June. 69 p. Available from: NTIS; PB 82-263443.



Key words: generalized inverses; Hamiltonian mechanics; Lie algebras; nonlinear oscillations; normalization; representation theory.

Representation theory of Lie algebras is called upon to develop a procedure for normalizing a dynamical system with two degrees of freedom in the neighbourhood of an equilibrium when the Hamiltonian  $H(x,y,X,Y)$  in the coordinates  $(x,y)$  and their conjugate momenta  $(X,Y)$  is of the type  $H=(X^2+Y^2)/2+V(x,y,X,Y)$ , the potential energy  $V$  being a sum of homogeneous polynomials in the phase variables of degree strictly greater than two. The fact that the resulting potential  $V'$  is a polynomial in the new coordinates  $(x',y')$  and the angular momentum  $G'=x'Y'-y'X'$  implies that the normalization is a rotation in the configuration space from a fixed frame to an ideal frame. The technique is intended for normalization is a rotation in the configuration space from a fixed frame to an ideal frame. The technique is intended for normalizing an Hamiltonian in equilibrium at the origin when the Lie derivative associated with the quadratic part is not semi-simple, e.g., the planar Restricted Problem of Three Bodies at the equilateral equilibrium  $L_4$  when the basic frequencies are equal (Routh's singular case).

**NBSIR 82-2545.** Ives, L. K.; Peterson, M. B.; Harris, J. S.; Boyer, P. A.; Ruff, A. W. Investigation of the lubrication mechanisms of the complex metal sulfide,  $SbSbS_4$ . 1982 July. 69 p. Available from: NTIS; PB 82-258922.

Key words: antimony thioantimonate; electron microscopy; lubricant additive; solid lubricant; wear; wear debris.

Studies have been carried out to determine certain basic properties of the complex metal sulfide,  $SbSbS_4$ , that pertain to its use as a solid lubricant and lubricant additive material. Past research had demonstrated that this material exhibited superior extreme pressure (EP) performance, antiwear properties, and high temperature stability. The present research has verified the performance under EP conditions as an additive to a base grease. However, the performance of  $SbSbS_4$  as a solid lubricant (in the form of a powder) was not found to be effective at temperatures below about 225°C. It was noted though that when used as a dry powder lubricant, the compound did produce a thick adherent film on steel surfaces in sliding contact. Six different types of wear and friction tests were carried out under various conditions of load, sliding speed, contact geometry, temperature, and time, in order to fully explore the potential of  $SbSbS_4$  as a lubricant on several different metals. In a number of cases, its performance was compared with  $MoS_2$  and with other sulfur containing additives in lubricants. Electron microscopy studies on film material removed from the sliding contact surfaces have shown that the interaction of sulfur released from  $SbSbS_4$  with the steel surface, presumably at locally elevated temperatures, is a principal mechanism. However, the physical characteristics of the  $SbSbS_4$  film in the contact zone probably also have a significant role in its overall performance.

**NBSIR 82-2548.** Carver, G. P.; Mattis, R. L.; Buehler, M. G. Design considerations for the cross-bridge sheet resistor. 1982 July. 21 p. Available from: NTIS; PB 82-252354.

Key words: cross-bridge structure; linewidth; microelectronic test structure; process control; sheet resistance; test structure.

The cross-bridge sheet resistor test structure is used to obtain the sheet resistance and electrical linewidth of a conducting layer. It has been used to characterize various conducting layers found in an integrated circuit fabrication process and to evaluate lithographic equipment used for processing photomasks and wafers. Three geometrical design factors for the cross bridge have been investigated and are shown to cause systematic inaccuracies of less than one percent in the sheet resistance and linewidth measurements. Based upon experimental results from sequences of devices with incrementally different geometrical parameters, several design criteria for the cross-bridge sheet resistor have been established.

**NBSIR 82-2549.** O'Brien, T. C. NBS and industrial biotechnology: Technical developments and future measurement needs. 1982 July. 180 p. Available from: NTIS; PB 82-253527.

Key words: biomass conversion R&D; bioprocess engineering; biotechnology; chemical industry trends/strategies; commodity organic chemicals; measurement/evaluated data needs; NBS

research capabilities.

Biotechnology will be a significant industrial technology in the future. NBS's role with respect to this technology is examined; and infrastructure support requirements needed by future biotechnology based industries are identified in this report. This report also describes steps NBS could take to meet future industry infrastructure support needs in biotechnology by: examining commodity organic chemical industry trends; identifying R&D opportunities and barriers to commercialization of biotechnology products; and evaluating current NBS capabilities in relation to long-term industry needs.

Report conclusions indicate that: (a) the commodity organic chemical industry will undergo structural changes in the next two decades; (b) early applications of biotechnology will be in higher value added products; (c) "traditional" commodity chemicals synthesized from petroleum feedstocks will be difficult to displace via biotechnological process; (d) biotechnology offers significant opportunities for production of "nontraditional" commodity organic chemicals; (e) biomass may become an important feedstock for production of organic chemicals; and (f) existing NBS capabilities could meet many of industry long-term infrastructure support needs in biotechnology.

This report provides a framework for possible short- and long-term actions NBS could take to meet industry needs in biotechnology. Report includes an extensive bibliography.

**NBSIR 82-2550.** Berger, M. J.; Seltzer, S. M. Stopping powers and ranges of electrons and positrons. 1982 August. 164 p. Available from: NTIS; PB 83-100289.

Key words: collision stopping power; electrons; positrons; radiation yield; radiative stopping power; range.

Tables of stopping powers and related data are given for electrons in 37 elements and 60 compounds, and for positrons in 8 materials. The tables include (1) collision stopping powers, (2) radiative stopping powers, (3) total stopping powers, (4) ranges (computed in the continuous-slowing-down approximation), (5) radiation yields (fraction of electron energy converted into bremsstrahlung), and (6) the logarithmic derivatives of all these quantities with respect to the mean excitation energy of the medium. These results are given at 81 energies between 1000 MeV and 10 keV. Restricted collision stopping powers are tabulated for selected materials, with cut-off energies of 1, 10 and 100 keV. The principal new ingredients in the preparation of these tables were: (1) a revision and updating of the mean excitation energies which enter into the Bethe stopping-power formula, on the basis of the best available data from stopping-power measurements and analyses of experimental oscillator-strength distributions and dielectric-response functions; (2) use of the general formulation of Sternheimer and Peierls for the density-effect correction to the collision stopping power; and (3) use of theoretical bremsstrahlung cross sections of Tsena and Pratt.

**NBSIR 82-2551.** Gomberg, A.; Buchbinder, B.; Offensend, F. L. Evaluating alternative strategies for reducing residential fire loss—The fire loss model. 1982 August. 66 p. Available from: NTIS; PB 82-263369.

Key words: cost benefit analysis; decision analysis; fire losses; fire safety; residential buildings; smoke detectors; sprinkler systems.

This report provides a preliminary documentation of a decision analysis framework for evaluating alternative residential fire loss reduction strategies. The framework, when it is completed, will provide a systematic means for assessing the costs and losses occurring under different intervention strategies. The current report focuses entirely on the problem of assessing fire losses, as this is where most of the uncertainty on system performance occurs. Subsequent reports will address the cost of the alternatives, after which the alternatives can be compared on a comprehensive cost/benefit basis.

Three alternatives are considered in this preliminary report: smoke detectors, residential sprinkler systems with standard commercial-type sprinkler heads, and a combination of both measures. Based on the preliminary input data developed, the preliminary analysis indicates that both sprinklers and detectors are effective in reducing life loss. Detectors appear to be somewhat more effective in reducing personal losses, however, because of their earlier warning capability. Sprinklers appear to be significantly more effective than detectors in reducing property loss because of their earlier start in initiating



suppression. Work is underway refining the loss model and developing a cost model so that meaningful cost/benefit comparisons of the alternatives can be conducted.

**NBSIR 82-2552.** Thurber, W. R.; Phillips, W. E.; Larrabee, R. D. **Measurement techniques for high power semiconductor materials and devices: Annual Report, October 1, 1980 to December 31, 1981.** 1982 August. 65 p. Available from: NTIS; PB 83-100321.

**Key words:** deep-level measurements; deep-level transient spectroscopy; defect characterization; lifetime; power-device grade silicon; transient capacitance techniques.

This annual report describes results of NBS research directed toward the development of measurement methods for semiconductor materials and devices which will lead to more effective use of high-power semiconductor devices in applications for energy generation, transmission, conversion, and conservation. Emphasis is on the development of measurement methods for power-device grade silicon. Major accomplishments during this reporting period were: (1) characterizing by deep level transient spectroscopy (DLTS) the energy levels in silicon power rectifier diodes, (2) writing of a computer program to predict lifetime-related parameters using as input the measured properties of the deep energy levels, (3) developing a novel method to detect nonexponential transients using a conventional double-boxcar DLTS system, (4) analyzing transient capacitance measurements to extend the techniques to nonexponential decays, (5) using a platinum resistance thermometer to calibrate temperature sensing diodes to obtain the precision needed for careful isothermal capacitance measurements, and (6) utilizing trap changing time as a technique to resolve overlapping DLTS peaks in sulfur-doped silicon.

**NBSIR 82-2553.** Seiler, J. F.; Campbell, P. G. **Development of interim performance criteria for restoration coatings for porcelain enamel surfaces.** 1982 July. 56 p. Available from: NTIS; PB 82-252024.

**Key words:** accelerated bathtub exposure cycle; performance criteria for restoration coatings; porcelain enamel restoration; restoration coatings.

A study was performed to develop interim performance criteria for restoration coatings for porcelain enamel surfaces. The laboratory study consisted of evaluating five restoration coatings which had been applied to porcelain enamel test panels with various surface conditions. Performance characteristics of the coatings examined included appearance, adhesion, impact resistance, stain resistance and fungal resistance. Existing test methods were used in the study if appropriate methods were available. However, the laboratory studies led to the development of a new cyclic exposure test and the use of a newly developed method for measuring adhesion. Adhesion of the coatings was the performance characteristic most sensitive to change with time of exposure to the newly developed cyclic exposure test. Interim performance criteria for restoration coatings for porcelain enamel surfaces were developed, based upon the results of the laboratory study.

Additional studies are being conducted to assess the performance and durability of selected restoration coatings applied to bath tubs in public housing units. Since the field studies are not yet completed, they are not addressed in this report.

**NBSIR 82-2554.** Metz, F. E.; Pielert, J. H.; Cooke, P. W.; Walton, D. **Health and safety considerations for passive solar heated and cooled buildings.** 1982 August. 65 p. Available from: NTIS; PB 82-263336.

**Key words:** building regulations; buildings; energy; enforcement; health and safety; passive design; solar energy; standards.

Passive solar buildings often introduce alternative construction techniques, and new materials and applications which presently have limited guidelines concerning safe application. This report discusses research conducted to pursue the nature of health and safety considerations in application of solar passive technology to buildings and how they would be affected by current building regulatory requirements. Health and safety considerations associated with solar passive systems are discussed including: indoor air quality; structural safety; fire safety; and environmental issues such as ventilation, illumination, temperature control, humidity and noise control. The report also identifies technical issues and research needs for addressing health and safety issues in passive solar technology.

**NBSIR 82-2556.** Quintiere, J.; Birky, M.; McDonald, F.; Smith, G. **An analysis of smoldering fires in closed compartments and their hazard due to carbon monoxide.** 1982 July. 42 p. Available from: NTIS; PB 82-257684.

**Key words:** building fires; carbon monoxide; compartment fires; smoldering.

A review was made of smoldering fire experiments conducted in closed room and buildings. The results were summarized by tabulating maximum levels of CO, the time integral of CO concentration ("dose"), CO<sub>2</sub>, temperature rise and oxygen consumption. A hazard time based on the attainment of a CO dose equal to 4.5% CO-minutes and the time for transition to flaming were also tabulated. The likelihood of reaching a critical CO condition during smoldering seems to be comparable to the likelihood of having transition to flaming occur. A theoretical model, requiring inputs of CO production rate and energy release rate, was executed and compared with available data. The theoretical results for CO concentration as a function of time were in good agreement with the experimental data. The model offers a means of extrapolating test data to compartments of various size in order to assess the general hazard of CO due to smoldering.

**NBSIR 82-2557.** Quintiere, J.; Harkleroad, M.; Walton, D. **Measurement of material flame spread properties.** 1982 August. 46 p. Available from: NTIS; PB 83-101931.

**Key words:** fire models; fire tests; flame spread; ignition; particle board.

A concept was examined for measuring flame spread parameters suitable for predicting the performance of a material in fires. The study examines a radiant panel test apparatus used to measure downward and lateral flame spread, and ignition. An analysis of data from tests of Douglas fir particle board is presented. A procedure has been identified for measuring specific parameters useful in the general prediction of ignition and flame spread for complex materials.

**NBSIR 82-2558.** Clark, L. P. **A life-cycle cost analysis methodology for fire protection systems in new health care facilities.** 1982 July. 41 p. Available from: NTIS; PB 82-258914.

**Key words:** automatic sprinklers; building codes; building construction; health care facilities; life cycle cost; Life Safety Code.

An analytical procedure is presented for conducting life-cycle cost (LCC) analyses of fire safety in new health care facilities. Comparative LCC evaluations of alternative fire safety systems can be obtained based on their initial costs, useful life times, operation and maintenance costs, salvage values, and corresponding fire insurance costs for the building and its contents.

The case study used to demonstrate the procedure compares the life-cycle costs of two fire safety systems in compliance with the NFPA Life Safety Code in a particular hospital: (1) fire resistive construction with no sprinklers, and (2) protected noncombustible construction fully equipped with automatic sprinklers.

Five different examples are provided with varying assumptions regarding initial construction costs, the choice of a discount rate, the tax status of the facility, and the life expectancy of the sprinkler equipment.

**NBSIR 82-2559.** Robinson, D.; Federman, C. **Evaluation of chain saw kickback motion using an optoelectronic measurement system.** 1982 August. 63 p. Available from: NTIS; PB 83-111666.

**Key words:** chain saw kickback motion; displacement measurements; kickback energy; optoelectronic measurement system; simulated kickback motion; volunteer test subjects.

In 1980 the Consumer Product Safety Commission initiated the in-house development of a mandatory standard to address chain saw kickback. Part of that effort involved relating known chain saw energy levels generated during kickback to the final angle that a saw might travel when held in the hands of a chain saw operator. The present report describes the experimental program developed at NBS to determine the relationship between kickback energy and chain saw



motion during hand-held kickbacks for selected samples of consumer-type chain saws and volunteer test subjects. The measurement system employed in this research included a computer-controlled optoelectronic system for measuring the displacements of selected points on the test saws and test fixture during simulated kickbacks. Included in the report is a description of the test equipment and procedures, the experimental design, and analyses of the measured displacement data for chain saws having known values of kickback energy.

**NBSIR 82-2560.** Manning, J. R. NBS: *Materials measurements*. 1982 July. 104 p. Available from: NTIS; PB 83-107854.

**Key words:** Auger spectroscopy; convection; gallium-tin alloys; levitation calorimetry; segregation; specific heat; surface tension; thermophysical properties; tungsten.

This report describes NBS work for NASA in support of NASA's Materials Processing in Space Program under NASA Government Order H-27954B (Properties of Electronic Materials) covering the period April 1, 1981 to March 31, 1982.

This work is directed toward measurement of materials properties important to the design and interpretation of space processing experiments and investigations of how the space environment may offer a unique opportunity for performing improved measurements and producing materials with improved properties. This work is being carried out in three independent tasks: Task 1. Surface Tensions and Their Variations with Temperature and Impurities. Task 2. Convection During Unidirectional Solidification. Task 3. Measurement of the High Temperature Thermophysical Properties of Tungsten Group Liquids and Solids.

Emphasis in Tasks 1 and 2 is on how the reduced gravity obtained in space flight can affect convection and solidification processes. Emphasis on Task 3 is toward development of techniques for thermodynamic measurements on reactive materials, requiring levitation and containerless processing.

**NBSIR 82-2562.** Nelson, H. E.; Shibe, A. J. A system for fire safety evaluation for multifamily housing. 1982 September. 159 p. Available from: NTIS; PB 83-119909.

**Key words:** building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems.

A qualitative evaluation system for grading multifamily housing in terms of fire safety has been developed and is ready for testing in Department of Housing and Urban Development field offices. The system is designed to be used to identify a variety of combinations of widely accepted fire safety equipment and building construction features that provide a level of safety equal or greater than that achieved by conformance to the explicit requirements of the HUD Minimum Property Standards. In this evaluation, equivalent safety performance is gauged in terms of overall level of safety provided rather than a component by component comparison.

**NBSIR 82-2563.** Fraker, A. C.; Ruff, A. W.; Bundy, K. J.; DeMontigny, S. A.; Sung, P.; Van Orden, A. C.; Speck, K. M. *Metallurgical studies of interface bonding on implant alloys*. 1982 October. 95 p. Available from: NTIS; PB 83-126698.

**Key words:** bone cement; hip prosthesis; stress analysis; surface preparation; surgical implant metals; test method; titanium.

A literature review covering articles on stress analyses in total hip replacement prostheses and the metal/bone cement interface is presented. The literature indicated the need for a test which utilized loading in torsion, and such a test was developed and is described. The test can be used to determine the influence of various parameters, including surface roughness and passivation and sterilization treatment on the strength of the metal/bone cement bond. Some preliminary tests were conducted and results are given. Future work using the mechanical test developed is discussed. Additional studies were conducted on the surface preparation of titanium, and data are presented to show that changes in initial electrochemical behavior and varying degrees of surface roughness occur depending on whether the metal receives a neutral, alkaline or acidic washing treatment.

**NBSIR 82-2567.** Turner, G. *An analysis of section 2.4 through 4.14 of the GSA proposed uniform Federal accessibility standard*. 1982 August. 58 p. Available from: NTIS; PB 82-260993.

**Key words:** accessibility; barrier-free design; building accessibility; database analysis.

Recently, the General Services Administration (GSA) developed a draft uniform accessibility standard (the focus of this report) intended to be promulgated in conjunction with the Department of Housing and Urban Development, the Department of Defense, and the United States Postal Service. Under contract to the General Services Administration, the National Bureau of Standards (NBS), Center for Building Technology assisted in the review of part 4, sections 4.2 through and including 4.14 of the draft standard in order to determine the extent to which previously identified problems of accessibility (NBS database) were addressed by the provisions of the standard. The analysis was carried out by reviewing and classifying the provisions of the draft standard; searching the NBS data base for information relevant to the classes of provisions in the draft standard; and comparing the provisions with the NBS database.

**NBSIR 82-2572.** Seltzer, S. M.; Berger, M. J. *Status of electron transport cross sections*. 1982 September. 30 p. Available from: NTIS; PB 83-112128.

**Key words:** bremsstrahlung; cross sections; elastic scattering; electron-impact ionization; electrons; photons; stopping power; transport.

This report describes recent developments and improvements pertaining to cross sections for electron-photon transport calculations. The topics discussed include: (1) electron stopping power (mean excitation energies, density-effect correction); (2) bremsstrahlung production by electrons (radiative stopping power, spectrum of emitted photons); (3) elastic scattering of electrons by atoms; (4) electron-impact ionization of atoms.

**NBSIR 82-2573.** Rosenthal, L.; Barkley, J. *An annotated bibliography of introductory articles to aid in the selection of small computer systems*. 1982 August. 20 p. Available from: NTIS; PB 83-134502.

**Key words:** microprocessors; personal computers; small computers; software; word processing.

A bibliography of references on personal computers has been compiled. The purpose in compiling this limited bibliography was to separate the articles on personal computing from those concerning the more general issues of computers and microprocessors.

**NBSIR 82-2575.** Kingston, M. L., ed. *NBS serial holdings 1982*. 1982 September. 288 p. Available from: NTIS; PB 83-132704.

**Key words:** annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; transactions.

This publication contains holdings information for approximately 4600 titles representing current and noncurrent journals, periodicals, annuals, memoirs, proceedings, and transactions. The holdings of the NBS Library and 3 collections specializing in fire research, standards, and diffusion in metals are represented.

**NBSIR 82-2578.** Cooper, L. Y.; Stroup, D. W. *Calculating available safe egress time (ASET)—A computer program and user's guide*. 1982 September. 137 p. Available from: NTIS; PB 83-117176.

**Key words:** combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits.

In the event of a fire in a building compartment the time available for occupants to safely evacuate the compartment, the Available Safe Egress Time (ASET), depends on the time of fire detection and on the time of the onset of hazardous conditions. In order to estimate these two times a dynamic simulation of the developing fire environment in the compartment is required. Also required are specific criteria for the simulation of detection and onset of hazard. A user oriented computer program which carries out the required simulations and provides estimates for the ASET has been developed. This document provides a listing of the program and a manual for its



use. For fire growth in a particular fuel assembly, a single program run can be used to evaluate the ASET from enclosures (which are assumed to contain the fuel assembly) of different heights and areas, and under a variety of different detection and hazard criteria. The program can be used in either an interactive or batch mode. It is written in ANSI Fortran and requires no computer specific subroutines.

**NBSIR 82-2580.** Kao, J. Y.; Parken, W. H.; Pierce, T. E. **Strategies for energy conservation for a large retail store.** 1982 September. 52 p. Available from: NTIS; PB 83-115543.

Key words: building control strategies; building energy conservation; building thermal performance; HVAC systems.

A comparative analysis is made of the thermal performance of selected HVAC systems and control strategies commonly employed in large retail stores. The comparisons are made for six geographical locations representing wide climatic variations within the continental United States. Hour-by-hour simulations with the BLAST computer program were used to obtain the yearly heating, cooling and fan energy consumption of a two-story large retail store. The HVAC systems simulated were constant volume reheat, variable air volume, and with direct expansion coils. The control strategies tested were dry bulb temperature economy cycle, enthalpy economy cycle, supply air temperature resetting, lowered space heating temperature, VAV zoning variations, and the combinations of these strategies. The results of these simulations were given and discussed. Substantial energy consumption differences were shown.

**NBSIR 82-2581.** Koch, W. F.; Marinenko, G.; Stolz, J. W. **Simulated precipitation reference materials, IV.** 1982 November. 20 p. Available from: NTIS; PB 83-139378.

Key words: acidity; acid rain; chemical analysis; conductance; pH; precipitation; rain; reference materials; trace elements.

This report describes work performed at the National Bureau of Standards under the sponsorship of the United States Environmental Protection Agency to establish the composition of a fourth series of reference materials intended to be used for the intercalibration of precipitation measurement stations, to evaluate the stability of the first three series of reference materials, to evaluate current methodologies for pH and acidity measurements, and to make recommendations to improve future reference materials and measurement protocols.

**NBSIR 82-2582.** Gevarter, W. B. **An overview of computer vision.** 1982 September. 170 p. Available from: NTIS; PB 83-115642.

Key words: artificial intelligence; automation; computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems.

This report provides an overview of computer vision. The emphasis is on image understanding and scene analysis, though pertinent aspects of pattern recognition are treated. Image processing for sensor correction, rectification, image enhancement, etc., is not covered.

This report reviews the basic approach to computer vision systems, the techniques utilized, applications, the current existing systems and state-of-the-art, issues and research requirements, who is doing it and who is funding it, and finally future trends and expectations. The intent is to provide an overall perspective of this vital field with its many participants, that will be useful to engineering and research managers, potential users and others who will be impacted by this field as it unfolds.

**NBSIR 82-2583.** Masters, L. W.; Seiler, J. F.; Roberts, W. E. **Outdoor exposure tests of solar absorptive coatings.** 1982 October. 22 p. Available from: NTIS; PB 83-124560.

Key words: absorptive coatings; accelerated laboratory exposures; degradation; outdoor exposures; simulated stagnation exposure; solar energy.

This report is a follow up to an earlier report (NBSIR 81-2232, January 1981) in which data on the performance of selected absorptive coatings in both accelerated laboratory exposures and outdoor exposures at three sites were presented. The research

presented in this report focuses upon the results obtained by continuing the outdoor exposures of absorptive coatings using ASTM E781-81, Standard Practice for Evaluating Absorptive Solar Receiver Materials When Exposed to Conditions Simulating Stagnation in Solar Collectors with Cover Plates.

Comparison of the results of the outdoor exposures with those obtained in accelerated laboratory exposures indicated that 1) the accelerated exposures, as described in ASTM E744-80, Standard Practice for Evaluating Solar Absorptive Materials for Thermal Applications, provide more severe exposure conditions than outdoor exposures, and 2) the degradation processes induced by outdoor exposure are adequately addressed by the accelerated laboratory exposures.

**NBSIR 82-2585.** Rubin, A. I. **Thermal comfort in passive solar buildings—An annotated bibliography.** 1982 October. 81 p. Available from: NTIS; PB 83-133595.

Key words: ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; thermal comfort.

This study consists of a selective annotated bibliography of thermal comfort research organized around major subject areas, and recommendations for future research concerned with thermal comfort in passive solar buildings. No attempt has been made to provide a comprehensive treatment of this extensive area of investigation—as this would be beyond the scope of the project under which this work was performed. Instead, the intent has been to sample the range of experimental variables and research methods employed by thermal comfort researchers—and to indicate significant findings.

The major goals for the present report are to describe the state-of-the-art of thermal comfort research and findings and to indicate the research needed to develop the information required by those responsible for specifying, designing and operating passive solar buildings.

**NBSIR 82-2586.** Hebner, R. E., ed. **Development of power system measurements—Quarterly Report April 1, 1982 to June 30, 1982.** 1982 October. 23 p. Available from: NTIS; PB 83-124891.

Key words: cables; dc fields; high voltage; incipient fault; insulation; SF<sub>6</sub>; space charge; transformer oil.

This report documents the progress on four technical investigations sponsored by the Department of Energy and performed by the Electrosystems Division, the National Bureau of Standards. The work described covers the period April 1, 1982 to June 30, 1982. This report emphasizes the errors associated with measurements of space charge near dc transmission lines, the measurement of rf attenuation in distribution cables, the characteristics of positive and negative corona in compressed SF<sub>6</sub> gas, and the measurement of the space charge density in transformer oil subjected to 60-Hz excitation.

**NBSIR 82-2587.** Gevantman, L. H. **Physical properties data for basalt.** 1982 September. 751 p. Available from: NTIS; PB 83-115311.

Key words: basalt; chemical characterization; data compilation; dielectric properties; electrical properties; mechanical properties; thermal properties; thermodynamic properties; thermophysical properties.

This work provides compiled experimental data and associated information on the thermodynamic, mechanical, thermophysical, and electrical properties of basalts from various locations in the United States and abroad. The thermodynamic properties include the chemical characterization of basalts, heat capacity, relative enthalpy, entropy, Gibbs energy, and molar volume. A summing procedure for obtaining values of heat capacity and calorimetric entropy above 298K is introduced.

**NBSIR 82-2588.** Moore, R. T. **HYBRID GRIDNET. Packet and circuit switching in a single network.** 1982 October. 62 p. Available from: NTIS; PB 83-136432.

Key words: alternate routing; circuit switching; communications networks; distributed control; integrated switching; packet switching survivability.



GRIDNET is a packet switching network, composed of multiply connected dual loops, being developed for the Defense Nuclear Agency in order to provide highly survivable data communications among a large number of sites. This report describes a concept for overlaying such a network with additional channels and switching facilities that may be used to establish point-to-point circuits on a demand basis. Switched connections are established following the exchange of appropriate frames between the stations that are involved. These exchanges use the regular GRIDNET packet switching facilities to provide essential supervisory and control functions including collision avoidance by means of circuit reservation in advance of connection. Switched circuits are automatically disconnected whenever no traffic is observed on them for a designated interval of time.

Alternate routing of a switched circuit is provided by the alternate routing algorithms that guide GRIDNET packets. These algorithms do not distinguish between candidate links that are unavailable because they are busy or because they are inoperable. In either case, an alternate route to the destination is selected as long as one exists.

**NBSIR 82-2590.** Yee, K. W. A guide for the construction and operation of Drill-Up. 1982 October. 26 p. Available from: NTIS; PB 83-140186.

Key words: drill breakage; Drill-Up; drill wear; time-domain analysis; tool breakage; vibration sensing.

This guide provides detailed information for the construction of a single-speed version of Drill-Up and instructions for its installation and operation. Drill-Up is an instrument designed to prevent breakage of small-diameter drills used on automatic-feed drilling machines with a spindle retract ability. The method and applications have been previously described in the references given. The hardware and software necessary to construct an instrument for use at a single selected drilling speed are described. The circuit diagram and source program are included. The description is of a preliminary design implemented at the National Bureau of Standards and in use in its central machine shop. Sufficient details are included for those equipped to use the common 8048 family of microcomputers to build a "cookbook" instrument. The information should be adequate for others, familiar with the use of any specific microcomputer or microprocessor, to implement the instrument on that device.

**NBSIR 82-2591.** Park, C.; David, A. J. Adaptive algorithm for the control of a building air handling unit. 1982 November. 48 p. Available from: NTIS; PB 83-142042.

Key words: adaptive control; air handling unit; direct digital control; energy management and control systems; HVAC system control; parameter estimator; PI-controller; recursive least squares algorithm; self-tuning control algorithm.

The use of adaptive control algorithms was studied for microprocessor driven direct digital control of elementary heating and cooling subsystems. An algorithm was designed for digital regulation of a linear, time-invariant first-order system with a system dead time. A recursive least squares algorithm was used to estimate, on-line, the parameters of the time-invariant linear system. The parameter estimates were then used to calculate the feedback gains of a Proportional plus Integral (PI) controller.

Through computer simulations, the adaptive-parameter PI-controller was compared with a constant-parameter PI-controller. On the basis of favorable simulation results, the adaptive algorithm was implemented for direct digital control of an air handling unit in a laboratory building at the National Bureau of Standards, Gaithersburg, Maryland. The convergence of the parameter estimates and the step response proved to be satisfactory provided the system was operating in a linear or weakly non-linear region, and was in steady or quasi-steady state. By selecting a proper scale factor, improved performance may be obtained when system characteristics vary.

**NBSIR 82-2593.** Carino, N. J.; Lew, H. S.; Stone, W. C.; Chung, R. M.; Hoblitzell, J. R. Investigation of construction failure of the Riley Road Interchange Ramp, East Chicago, Indiana. 1982 October. 213 p. Available from: NTIS; PB 83-124800.

Key words: bridge; collapse; concrete; construction; failure investigation; falsework; field load tests; formwork; post-tensioning; structural analysis.

The National Bureau of Standards (NBS), at the request of the Occupational Safety and Health Administration, conducted an investigation to determine the most likely cause of the collapse of a portion of a highway ramp in East Chicago, Indiana. The accident occurred on April 15, 1982, and resulted in the death of 13 workers. A team of engineers from NBS and the Federal Highway Administration carried out an extensive field investigation, in cooperation with personnel from the Indiana Occupational Safety and Health Administration, to ascertain the conditions prior to and after the accident. In addition, the NBS performed physical tests on key components of the temporary support system used to build the ramp. A structural analysis was also performed to compute the magnitude of the forces acting in various components of the support system. The calculated forces were compared with the expected strengths of these components. It is concluded that the most likely triggering mechanism of the collapse was the cracking of a concrete pad supporting a leg of the shoring towers. It is shown that this initial failure caused additional components to fail which ultimately led to the collapse of the support system and major segments of the partially completed ramp. It is further concluded that the following deficiencies contributed directly to the collapse of a unit of the ramp construction: 1) specified wedges were omitted between stringers and crossbeams; 2) the concrete pads supporting the shoring towers had an inadequate margin of safety to resist the expected loads; 3) the tops of the shoring towers were not adequately stabilized against longitudinal movement; and 4) the weld quality in the U-heads supporting the crossbeams was poor. Had any of these deficiencies not existed, it is unlikely that the collapse would have occurred. Additional deficiencies contributed to the subsequent collapse of another ramp unit. They were as follows: 1) specified one-inch bolts were not provided for connecting crossbeams to stringers and overlap beams; 2) special overlap beams at the piers were not constructed as specified; and 3) the construction sequence deviated from the specified sequence.



## 5.15 GRANT/CONTRACT REPORTS AND NBS PATENTS

Grant/contract reports are prepared by non-NBS persons or organizations working under grant or contract from the National Bureau of Standards. Those contract reports not incorporated into the formal NBS publication series are available directly from the National Technical Information Service (NTIS, Springfield, VA 22161) in paper copy or microfiche form unless otherwise stated. When ordering a report from NTIS you must order it by the "COM, PB, AD, or N" number as indicated.

Patents are legal documents which fully describe inventions in return for the right for 17 years to exclude others from making, using, or selling the inventions. They are obtained on NBS inventions of high commercial potential in order to establish Government ownership of the patent rights. The patents are then made available for the grant of nonexclusive licenses to all qualified applicants. A limited exclusive license may be granted under a particular patent, however, if it appears that some period of exclusivity is necessary as an incentive for the investment of risk capital. For information on licensing any of the following patents, write to the Office of the Legal Adviser, National Bureau of Standards, Washington, DC 20234. Copies of patents may be obtained from The U.S. Patent and Trademark Office, Washington, DC 20231 for 50 cents each.

**NBS-GCR-80-204.** Quate, C. F., (NBS contact: E. Cohen). **Innovative measurement technology for the semiconductor industry: The acoustic microscope—A new instrument for viewing integrated circuits.** 1980 May. 11 p. Available from: NTIS; PB 82-170499.

Key words: acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon.

Developments in acoustic microscopy are reported. The operating frequency of scanning acoustic microscopes has been increased from 350 MHz to above 2 GHz, with a resulting improvement in resolution approximating that of the best optical microscopy. An instrument operating in the reflection mode was developed and its design and construction technology were transferred to a group working at the Hughes Research Laboratories on a related program. The utility of the instrument for examination of integrated circuits was demonstrated.

The mechanisms by which contrast is produced in the acoustic microscope have been explained theoretically and verified experimentally. The theory has been used to understand the details of the "signature" response of the instrument as the distance from the lens to the specimen is varied. These responses differ markedly for different specimen materials and for layered structures of varying layer thickness, and may have considerable value for materials analysis studies.

The instrument reveals fundamentally different information about the specimen than is found with other kinds of microscopy, because it responds to variations in the density and elastic properties of the specimen. It therefore has value in studying other kinds of specimens than those which were the primary subject of this investigation.

**NBS-GCR-81-304.** You, H. Z.; Faeth, G. M., (NBS contact: N. Jason). **An investigation of fire impingement on a horizontal ceiling.** 1981 December. 83 p. Available from: NTIS; PB 82-165838.

Key words: ceilings; fire models; fire plumes; heat transfer; radiation; turbulence.

The structure and heat transfer properties of fires and fire plumes impinging on a horizontal ceiling were investigated. Profiles of mean velocity, temperature, composition and mixture fraction were measured. Turbulence quantities were also measured in the plume, including longitudinal fluctuations and Reynolds stress. Other measurements were as follows: convective and radiative heat fluxes to the ceiling, radiative heat flux to the surroundings, and flame shape.

The measurements were compared with predictions of both differential and integral models. A  $k-\epsilon$  differential model was examined for the plume portion of the flow. This model was originally developed for forced combustions flows and while it includes buoyancy effects in the mean equations, the effect of buoyancy on turbulence quantities is ignored. The prediction of

radiation was simplified, in order to avoid complications due to the presence of soot, by either neglecting radiative heat losses entirely or by assuming that a fixed fraction, 20%, of the energy released by combustion was lost due to radiation.

Integral models were developed for both the plume and ceiling jet portions of the flow. Computational convenience was emphasized during the construction of these models; therefore, "top-hat" profiles a flow entrainment expression, and a mixing-controlled combustion model are assumed.

**NBS-GCR-81-340.** Smith, D.; Rothnie, J.; Hsiao, D.; Manola, F.; Dayal, U. **A component architecture for database management systems.** 1980 June 18. 107 p. Available from: NTIS; PB 82-203621.

Key words: database management systems; data models; DBMS; DBMS architecture; standards.

This report presents an architecture for database management systems (DBMS's) that has been designed to provide a framework for developing database management standards. The architecture is based on the concept of a component. A component is a module of a DBMS which could be marketed as a product separately from the rest of the DBMS, such as a query language processor. Each DBMS component can have one or more interfaces to users and to other components. The objective of this component architecture is to identify all important interfaces, particularly those which would otherwise be internal to the DBMS architecture. Such interfaces have not previously been considered as candidates for standardization. By making appropriate interfaces standard, a market can be created for plug compatible pieces of a DBMS. In this manner, standardization activities will provide increased scope for DBMS product development.

**NBS-GCR-81-348.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **States' measurement needs study: Final report.** 1981 September 30. 143 p. Available from: NTIS; PB 82-163809.

Key words: analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; training.

The Association of State and Territorial Solid Waste Management Officials prepared a report on States' Measurement Needs in order to determine various measurement requirements under Subtitle C, Hazardous Waste Management Regulation; Subtitle D, Solid Waste Management and Subtitle E, Guidelines for Resource Recovery and Materials and Energy Recovery. The report consists of Part I: Final Report and Executive Summary; Part II: State Profiles (Texas, Louisiana, Oklahoma, Pennsylvania, Virginia, Mississippi); and, Part III: Analytical Operations Procedure Manual Model.

**NBS-GCR-81-349.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **State measurement needs study: Part II, State profile (Louisiana).** 1981 September 30. 141 p. Available from: NTIS; PB 82-163817.

Key words: analytical procedures; hazardous waste management; lab procedures; Louisiana; Resource Conservation and Recovery Act; test protocols; training.

The Association of State and Territorial Solid Waste Management Officials prepared report on State Measurement Needs in order to determine various measurement requirements under Subtitle C, Hazardous Waste Management Regulations; Subtitle D, Solid Waste management, and Subtitle E, Guidelines for Resource Recovery and Materials and Energy Recovery. This volume profiles State of Louisiana program, including but not limited to: (1) State compliance with Federal testing criteria under Subtitle C, RCRA; (2) State laboratory needs; (3) current training program and capabilities.

**NBS-GCR-81-350.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **State measurement needs study: Part II, State profile (Oklahoma).** 1981 September 30. 160 p. Available from: NTIS; PB 82-163833.

Key words: analytical procedures; hazardous waste management; lab procedures; Oklahoma; Resource Conservation and Recovery Act; test protocols; training.



The Association of State and Territorial Solid Waste Management Officials prepared report on State Measurement Needs in order to determine various measurement requirements under Subtitle C, Hazardous Waste Management Regulations; Subtitle D, Solid Waste Management, and Subtitle E, Guidelines for Resource Recovery and Materials and Energy Recovery. This volume profiles State of Oklahoma program, including but not limited to: (1) State compliance with Federal testing criteria under Subtitle C, RCRA; (2) State laboratory needs; (3) current training program and capabilities.

**NBS-GCR-81-351.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **State measurement needs study: Part II, State profile (Pennsylvania).** 1981 September 30. 149 p. Available from: NTIS; PB 82-163841.

Key words: analytical procedures; hazardous waste management; lab procedures; Pennsylvania; Resource Conservation and Recovery Act; test protocols; training.

The Association of State and Territorial Solid Waste Management Officials prepared report on State Measurement Needs in order to determine various measurement requirements under Subtitle C, Hazardous Waste Management Regulations; Subtitle D, Solid Waste Management, and Subtitle E, Guidelines for Resource Recovery and Materials and Energy Recovery. This volume profiles State of Pennsylvania program, including but not limited to: (1) State compliance with Federal testing criteria under Subtitle C, RCRA; (2) State laboratory needs; (3) current training program and capabilities.

**NBS-GCR-81-352.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **State measurement needs study: Part II, State profile (Texas).** 1981 September 30. 203 p. Available from: NTIS; PB 82-163858.

Key words: analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; Texas; training.

The Association of State and Territorial Solid Waste Management Officials prepared report on State Measurement Needs in order to determine various measurement requirements under Subtitle C, Hazardous Waste Management Regulations; Subtitle D, Solid Waste Management, and Subtitle E, Guidelines for Resource Recovery and Materials and Energy Recovery. This volume profiles State of Texas program, including but not limited to: (1) State compliance with Federal testing criteria under Subtitle C, RCRA; (2) State laboratory needs; (3) current training program and capabilities.

**NBS-GCR-81-353.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **State measurement needs study: Part II, State profile (Mississippi).** 1981 September. 155 p. Available from: NTIS; PB 82-163825.

Key words: analytical procedures; hazardous waste management; lab procedures; Mississippi; Resource Conservation and Recovery Act; test protocols; training.

The Association of State and Territorial Solid Waste Management Officials prepared report on State Measurement Needs in order to determine various measurement requirements under Subtitle C, Hazardous Waste Management Regulations; Subtitle D, Solid Waste Management, and Subtitle E, Guidelines for Resource Recovery and Materials and Energy Recovery. This volume profiles State of Mississippi program including but not limited to: (1) State compliance with Federal testing criteria under Subtitle C, RCRA; (2) State laboratory needs; (3) current training program and capabilities.

**NBS-GCR-81-354.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **State measurement needs study: Part II, State profile (Virginia).** 1981 September 30. 89 p. Available from: NTIS; PB 82-163866.

Key words: analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; training; Virginia.

The Association of State and Territorial Solid Waste Management Officials prepared report on State Measurement Needs in order to determine various measurement requirements under Subtitle C,

Hazardous Waste Management Regulations; Subtitle D, Solid Waste Management, and Subtitle E, Guidelines for Resource Recovery and Materials and Energy Recovery. This volume profiles State of Virginia program, including but not limited to: (1) State compliance with Federal testing criteria under Subtitle C, RCRA; (2) State laboratory needs; (3) current training program and capabilities.

**NBS-GCR-81-355.** Association of State and Territorial Solid Waste Management Officials, (NBS contact: T. Matthews). **State measurement needs study: Analytical operations procedure manual model.** 1981 September 30. 154 p. Available from: NTIS; PB 82-163874.

Key words: analytical procedures; hazardous waste management; lab procedures; model manual; monitoring; Resource Conservation and Recovery Act; State measurement needs; test protocols.

The Association of State and Territorial Solid Waste Management Officials identified the need for State-to-State consistency in implementing hazardous waste management regulations under Subtitle C, Resource Conservation and Recovery Act of 1976 (P.L. 94-580), as amended. The need for a technical guide for both the regulator and regulatee is necessary in order to provide for consistency and to guide the regulated community, particularly small businesses, in meeting the analytical regulatory requirements. The Association has proposed and details in this report such a framework. The report addresses: (1) identification of hazardous waste; (2) special test protocols; (3) hazardous constituents; (4) categories of wastes; (5) State measurement needs; analytical protocols and procedures and monitoring.

**NBS-GCR-81-356.** Urban Sciences, Inc., (NBS contact: M. Treado). **Digital communications techniques and equipment for law enforcement use.** 1982 January. 70 p. Available from: NTIS; PB 82-195496.

Key words: digital communications equipment; digital techniques; equipment standards; law enforcement; mobile digital terminals; voice message traffic.

This report is the result of a study of digital communications equipment for law enforcement use. The primary objective was to determine the suitability of the various types of this equipment for use by law enforcement agencies. The report reviews present voice message traffic on typical police radio networks and discusses operational requirements for digital communications equipment. It further reviews the possible applications of digital communications equipment for law enforcement use, and lists the characteristics of mobile digital terminals being offered at present. A brief technical discussion of mobile digital communications is also provided.

**NBS-GCR-81-363.** Wilson, R. G.; Weglein, R. D., (NBS contact: E. Cohen). **Reflection acoustic microscope measurement technology.** 1981 December. 9 p. Available from: NTIS; PB 82-165168.

Key words: acoustic material signatures; acoustic microscopy; scanning acoustic microscopy; semiconductor devices and integrated circuit inspection.

A scanning acoustic microscope operating at 0.4 GHz and employing water as an immersion fluid was developed for the inspection of semiconductor devices and integrated circuits. This instrument provides a new analysis technique that is sensitive to material properties, namely, the mass density and elastic stiffness. Our research with this technique shows that acoustic microscopy will also find useful applications in material research and nondestructive evaluation in general. In particular, we discovered a mode of operation that characterizes materials by generating what we call acoustic emission signatures. Changes in the acoustic impedance at interfaces make shallow interfaces observable. With the acoustic microscope, it is possible to display some subsurface features that cannot be seen using optical or scanning electron microscopes. Factors that change the local density of materials, such as temperature or strain, also may affect the acoustic velocity and impedance and therefore the acoustic image.

**NBS-GCR-81-364.** Johnson, N. M., (NBS contact: E. Cohen). **DLTS analysis of residual damage in low-dose ion-implanted silicon.** 1982 February. 24 p. Available from: NTIS; PB 82-178690.



Key words: deep-level transient spectroscopy (DLTS); defect levels; dopant profiles; furnace anneal; ion implant; silicon.

Transient capacitance spectroscopy was used to measure the energy levels and spatial distributions of residual damage in low-dose ion-implanted silicon. The results indicate that a 800°C 30-min anneal in flowing nitrogen successfully reduces arsenic ion-implantation damage to levels not expected to significantly influence C-V measurements of dopant profiles.

**NBS-GCR-81-365.** Maxwell, T. T.; Dyer, D. F.; Maples, G.; Burch, T., (NBS contact: N. Jason). *An investigation of creosoting and fireplace inserts.* 1981 December. 108 p. Available from: NTIS; PB 82-169145.

Key words: chimneys; creosote; fire safety; flues; heating equipment; stoves; tar; temperature measurements; wood.

Estimates indicate that there are between 15 and 30 million fireplaces in existence in the United States. The use of fireplace inserts could provide primary heating sources for many of the homes in which they are located. This report presents the results of a testing program to quantify safety problems in the areas of chimney creosoting, efficiency and thermal performance of the inserts when used in masonry and factory-built fireplaces.

The most important factors affecting creosote formation were found to be appliance type, moisture content and wood type. However, significant levels of creosote were formed with all fuels tested. This indicates that there is no "safe" wood to burn which will not produce creosote. Further, it emphasizes the necessity of routine maintenance on the part of homeowners who heat with wood.

**NBS-GCR-82-366.** Resource Recovery Subsection, Dept. of Environmental Regulation, State of Florida, (NBS contact: Office of Recycled Materials), *National Recycling Directory.* 1982 January. 157 p. Available from: NTIS; PB 82-178005.

Key words: directory; ferrous metals; glass; nonferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles.

The directory focuses on manufacturers and/or distributors of products made from waste materials. Companies listed in the directory manufacture products which contain some recycled or recovered material. The directory consists of separate sections for the types of recycled materials used: glass, ferrous metals, non-ferrous metals, paper, plastic, rubber, and textiles. The states are listed alphabetically within each subsection, and the companies are listed alphabetically under the state in which they are located.

**NBS-GCR-82-367.** Jeng, S. M.; Chen, L. D.; Faeth, G. M., (NBS contact: N. Jason). *An investigation of axisymmetric buoyant turbulent diffusion flames.* 1982 January. 88 p. Available from: NTIS; PB 82-165176.

Key words: buoyancy; diffusion flames; flame research; heat flux; methane.

This investigation considered measurements of the structure of axisymmetric, buoyant, turbulent diffusion flames in still air. Profiles of mean temperature, mean velocity, velocity fluctuations and total radiant heat flux were completed for methane flames, including careful characterization of burner exit conditions, in order to provide data for the evaluation of models of the process. Preliminary tests also provided mean temperature profiles for propane flames. Test conditions were chosen so that the flow was turbulent near the burner exit while effects of buoyancy were significant over most of the luminous portion of the flames. Both the present measurements and those of other investigators were compared with predictions of a k-ε-g differential model, which included effects of buoyancy in the transport equations for turbulence quantities. The results indicated anisotropic effects in regions where buoyancy dominates flow properties suggesting the eventual desirability of multi-stress models for buoyant flames, although extensive recalibration of model constants from a limited data based would be required if this step were taken. Additional measurements and analysis of methane flames are in progress, in order to investigate the flame radiation properties and provide additional data on turbulence properties needed for

model development.

**NBS-GCR-82-368.** Terpstra, W. R.; Jorgenson, M. L.; Dosedlo, L. J., (NBS contact: N. Jason). *Investigation of fire hazards of fireplace inserts in factory-built and masonry fireplaces.* 1982 January. 81 p. Available from: NTIS; PB 82-184045.

Key words: chimneys; creosote; fire safety; fire tests; flues; heating equipment; stoves; wood.

This report describes an investigation of fireplace inserts installed in factory-built and masonry fireplaces for use as solid fuel burning, residential heaters. The objective of the program was to develop information on temperatures that occur in such fireplace/fireplace insert combinations, and at adjacent combustible materials during continuous firing of the fireplace/fireplace insert combination. Presently recommended practices for construction of fireplaces were reviewed, and several fireplace and insert combinations were fire tested. The program considered (1) material, construction and structural aspects, (2) securement and stability of the fireplace insert, (3) chimney connections, (4) temperature rise, and (5) leakage of combustion products.

**NBS-GCR-82-370.** Clemons, E. K.; Hanks, S.; Pastor, J. A. *Access control language syntax and semantics: Final report.* 1982 April 1. 44 p. Available from: NTIS; PB 82-227083.

Key words: access control; CODASYL; database management system; DBMS; network data model.

This paper presents a language to provide enhanced access control capabilities for network data base management systems. The architecture of a proposed access control facility is reviewed, and its language and interface requirements discussed. The functional requirements for the language are enumerated, and its syntax and semantics are described. Language facilities are provided for access control definition and update, and for inquiries concerning access privileges granted. The language is designed such that it may be used for initial definition, update, or query of access privileges, in either batch or interactive mode. The access control system proposed is at the schema level, rather than at the subschema level, and is stand-alone, rather than embedded in the schema definition processor. Finally, the facility is based on granting or denying rights to roles that may be occupied by one or more users, in contrast to the lock and key approach originally proposed by the CODASYL Data Base Task Group and perpetuated through subsequent data description language specifications.

**NBS-GCR-82-371.** Barton, D. R.; Friedman, D. B.; Post, H. A.; Williams, F. E., (NBS contact: T. Matthews). *Marketing information report: Waste newspapers in four South Atlantic States 1980.* 1981 October. 91 p. Available from: NTIS; PB 82-170382.

Key words: cellulosic insulation; Florida; Georgia; newspaper recovery; North Carolina; resource recovery; South Carolina.

The report was prepared to provide data on the markets for wastepapers in North and South Carolina, Georgia and Florida. The report is not intended to promote one market over another or draw conclusions regarding whether or not a specific resource recovery facility should burn waste newspaper. Survey indicates growth in demand for waste newspapers. Bibliographics include directory of waste newspaper markets, glossary and old news standards; cellulose insulation demand.

**NBS-GCR-82-372.** Sibley, E. H., (NBS contact: J. Draper). *A functional specification of the relational DBMS.* 1982 January. 99 p. Available from: NTIS; PB 82-182965.

Key words: database management; DBMS; functional specification; mandatory requirements; optional requirements; procurement; relational; standards.

A functional specification is a description of the way that a system shall operate, with every attempt made to remove from the specification any syntactical details of the interface. Here a set of mandatory and optional functions is specified for a "relational calculus" interface to a relational database management system (R-DBMS).

The document is intended to be self-contained—a data processing manager or technician should be able to read and understand the



material without prior knowledge of database management. Thus a basic description of database management and the relational method precedes the mandatory specification. The second part discusses the need for extensions to this basic specification and provides a set of generally distinct additions that the user may choose to require. The final selection examines two well-known systems (INGRES of UC Berkeley and SQL/DS of IBM) for their degree of compliance with the mandatory functions. This comparison shows that either the mandatory requirements are too rigid, or that current systems have some practical deficiencies.

The purposes of this specification are therefore: (1) to show the form that a functional specification should take, examining it for completeness; and (2) to allow Federal procurement of relational DBMS within a contractual specification.

**NBS-GCR-82-373.** Su, S. Y. W.; Batory, D. S.; Dujmovic, J. J.; Elnicki, R.; Navathe, S. B.; Olagunju, A.; Parkes, J., (NBS contact: J. Collica). **A DBMS cost/benefit decision model: Cost and preference parameters.** 1981 January. 393 p. Available from: NTIS; PB 82-169566.

**Key words:** cost parameters; database management; data management evaluation; DBMS; decision model; preference parameters; requirements.

This report presents the general cost and preference parameters for the evaluation, comparison, and selection of data management alternatives. The parameters are derived systematically by using a hierarchical decomposition technique. The decomposition process starts with the basic categories of system requirements and terminates when sufficiently simple cost and preference parameters are derived based on which costs and preference measures of data management alternatives can be determined. The derived parameters are to be used by a quantitative analytic decision model for complex data management system evaluation and comparison. The role of the decision model in the system life cycle is discussed and the concept of system-requirement-based analysis of cost and preference analysis is introduced. An exhaustive list of parameters is accompanied by an appropriate description and justification for the existence of each parameter.

**NBS-GCR-82-374.** Dujmovic, J. J.; Elnicki, R., (NBS contact: J. Collica). **A DMS cost/benefit decision model: Mathematical models for data management system evaluation, comparison and selection.** 1981 July. 155 p. Available from: NTIS; PB 82-170150.

**Key words:** cost parameters; DBMS; database management; data management; data management evaluation; decision model; preference parameters; requirements.

A detailed description of the LSP method is presented in this report. The main topics include: (1) development of system requirement tree; (2) detailed classification and description of elementary criteria; (3) logic aggregation of preference; (4) the analysis of elementary and compound preference aggregation functions; (5) cost analysis models for data management systems; and (6) a detailed presentation of the cost-preference analysis for system comparison and selection.

This report is the first part of the second deliverable under the NBS Contract No. NB80SBCA0449. The second deliverable presents mathematical models for data management system evaluation and selection. The first part of the second deliverable (i.e., this report) is aimed at providing general mathematical models for system evaluation, comparison, and selection. The second part of the second deliverable (i.e., the subsequent report) presents the mathematical models for data management system evaluation and selection using the general methodology introduced in this report.

**NBS-GCR-82-375.** Su, S. Y. W.; Batory, D. S.; Navathe, S. B.; Olagunju, A.; Parkes, J., (NBS contact: J. Collica). **A DMS cost/benefit decision model: Analysis, comparison, and selection of DBMS's.** 1981 July. 217 p. Available from: NTIS; PB 82-168857.

**Key words:** cost parameters; DBMS; database management; data management; data management evaluation; decision model; preference parameters; requirements.

This report uses a hypothetical DMS decision problem to present the procedure of analysis, comparison, and selection of a data management system and to demonstrate the practical application of

the decision model presented in our earlier reports. The analysis, comparison and selection of DMS's is carried out in the following steps: (1) select cost and preference (or performance) parameters; (2) formulate elementary criteria; (3) aggregate preferences; (4) issue RFP to vendors to get the official proposals containing all required data specifying the costs and capabilities of alternative systems; (5) compute the global preference of each competitive system and perform sensitivity analysis; (6) compute the global costs of competitive systems; and (7) perform cost-preference analysis to rank the systems. Examples are given to illustrate the procedures and techniques which can be used in each step to systematically evaluate the alternative systems. Some 120 elementary criteria and a criterion aggregation structure designed for DBMS analysis, comparison, and selection are provided in this report. They can be used as a guide to the users of the DMS cost/benefit decision model to formulate criteria and aggregation structures for their own decision situations.

**NBS-GCR-82-376.** Bray, G.; Lipset, R.; Bail, W.; Berman, V., (NBS contact: R. Houghton). **PASCAL compiler functional specification.** 1980 December. 40 p. Available from: NTIS; PB 82-183989.

**Key words:** compilers; dynamic analysis; programming aids; software development; software engineering; software tools; static analysis.

A functional specification for a PASCAL compiler system is reported that incorporates an integrated set of software development capabilities. The capabilities include automated support for program design, documentation, implementation, debugging, and maintenance.

**NBS-GCR-82-377.** Carrier, G.; Fendell, F.; Fink, S., (NBS contact: N. Jason). **Towards wind-aided flame spread along a horizontal charring slab: The steady-flow problem.** 1982 February. 86 p. Available from: NTIS; PB 82-183732.

**Key words:** ceilings; charring; compartment fires; corridors; flame spread; polymers; room fires; thermal degradation.

The spread of fire across the ceiling of a large room (or long corridor) in a structure is modeled as wind-aided flame spread along a horizontal *char-forming* thick slab, in the presence of significant convective, diffusive, and *radiative* transport. The goal is to predict the rate of streamwise advance of the site on the solid-gas interface at which the pristine solid undergoes endothermic degradation to a combination of (1) a porous carbonaceous heat-retaining matrix, and (2) a mixture of (partially combustible) vapors that move through the matrix to the outer gas. This rate of advance of the thermal-degradation site is sought as a function of normally available data concerning the thermodynamic and physical properties of the solid and the thermodynamic and dynamic state of the hot vitiated bulk gas that flows over the slab. A *nonlinear*, unsteady, two-spatial-dimension treatment in the Shvab-Zeldovich approximation entails boundary-layer simplification in the manner of Prandtl convective-transport simplification in the manner of Oseen, and thin-flame simplification in the manner of Burke and Schumann. Whereas the formulation given here is general and is to be solved in subsequent work for a partially involved slab, the solution here is limited to the steady-state problem.

**NBS-GCR-82-378.** Murphy, R. B. **Molecular biophysics of olfaction—Report of progress.** 1982 April. 33 p. Available from: NTIS; PB 82-205782.

**Key words:** chemical analysis; electrochemistry; membranes; olfaction; protein separation.

This report summarizes progress in the Olfactory Research Program at the Department of Chemistry, New York University, under Prof. Randall B. Murphy. The report is divided into three technical sections: Biochemistry, Biophysics, and Practical Olfactory Device. In the first area, methods are described for the preparation of homogenates from the olfactory epithelium which contain principally ciliary protein fractions. The preliminary biochemical characterization of these homogenates, including binding studies with <sup>35</sup>S labeled alkyl sulphides, is detailed. Experiments designed to relate biochemical composition to ultrastructure of the rat olfactory epithelium are described. In the biophysical studies, the procedure for monitoring functional reconstitution is detailed, utilizing both the technique of surface pressure quantitation of lipid-protein monolayers, as well as more conventional approaches such as construction of lipid bilayer membranes containing reconstituted olfactory fractions. The



construction of novel experimental apparatus for the monitoring of the electrochemical properties of such bilayer membranes, designed around a computer-based voltage measurement system as described. The final section of the report deals with the use of this apparatus to test the feasibility of a practical olfactory device.

**NBS-GCR-82-379.** Brodie, M. K.; Schmidt, J. W., eds., (NBS contact: J. Draper). *Final report of the ANSI/X3/SPARC DBS-SG relational database task group.* 1982 February. 166 p. Available from: NTIS; PB 82-170051.

**Key words:** American National Standards Institute; computer standards; DBMS; database management; database standards; Data Base System Study Group; query language; relation; relational model; Relational Task Group.

This is the Final Report of the Relational Task Group (RTG), a task group of the American National Standards Institute (ANSI) subordinate to the ANSI/X3/SPARC Data Base Systems Study Group (DBSSG) currently chaired by W. Terry Hardgrave of the Institute for Computer Sciences and Technology of the National Bureau of Standards.

In May 1979, the RTG was chartered to investigate Relational Database Management Systems and to propose a standards project if appropriate. The RTG produced this report and some supplemental material plus a proposal for a relational DBMS standards project. The report describes the relational model, catalogs the features of current relational systems, discusses architectural issues related to relational systems, and makes recommendations for developing a relational standard.

**NBS-GCR-82-382.** Mohr, J. M.; Wilson, C. B.; Chan, P. M. C. *An approach to ADP user service reporting.* 1982 March. 96 p. Available from: NTIS; PB 82-195025.

**Key words:** ADP effectiveness; computer performance evaluation (CPE); computer performance management (CPM); service levels; user service reporting system (USRS).

An approach to ADP user service reporting is presented which uses the maximization of Net Benefit to the Organization (NBO) as the basic criterion for determining the needed level of ADP service. The goal of the User Service Reporting System (USRS) is to provide each of the groups within the management hierarchy with timely feedback on how well the ADP installation is supporting the needs of the organization. The report discusses the calculation of costs and benefits as well as factors affecting their optimization. The report identifies work units and service measures which are appropriate for a USRS. The usefulness and measurability of the proposed work units and service measures are discussed. A significant bibliography is included in this report.

**NBS-GCR-82-383.** Kennett, E. W., ed. *Proceedings of the 1980 conference on life safety and the handicapped.* 1982 March. 116 p. Available from: NTIS; PB 82-194515.

**Key words:** building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge.

Our society has made a conscious decision to integrate the handicapped into the "mainstream" of everyday life. Significant progress has been made toward making buildings accessible to the handicapped, but this very success brings a concomitant responsibility for dealing with the problem of protection and emergency exit. Simply stated, ingress implies egress. The 1980 Conference on Life Safety and the Handicapped was another step in an ongoing process of responsibly addressing this issue. The objectives were education, articulation, and formulation: education as to the overall existence of the issue, articulation of specific problems and needs, and formulation of a national agenda for how to address the issue. Toward the goal of formulating a National Agenda, a significant portion of the conference was devoted to a set of twelve workshops. Sixteen topic papers were presented during the conference. Seventeen consensus recommendations were produced in the final plenary session. The conference was produced by the National Task Force on Life Safety and the Handicapped and AIA Research Corporation; sponsored by the National Bureau of Standards; and funded by the Veterans Administration, the Federal Emergency Management Agency, the

U.S. Department of Health and Human Services, and the U.S. Department of Labor. *These proceedings include the following papers (indented):*

**NBS-GCR-82-383;** 1982 March. 12-13. Burgun, J. A. *Life Safety Codes.*

**NBS-GCR-82-383;** 1982 March. 14-18. Benjamin, I. *Life Safety Codes—Current state of regulations providing safety considerations in buildings accessible to the handicapped.*

**NBS-GCR-82-383;** 1982 March. 19-26. Nelson, H. *1979 conference on life safety and the handicapped.*

**NBS-GCR-82-383;** 1982 March. 27-32. Blizzard, E. *Emergency planning.*

**NBS-GCR-82-383;** 1982 March. 33-35. Kuns, J. *Public education.*

**NBS-GCR-82-383;** 1982 March. 36-38. Jameson, F. *Notification and alarm systems—The Las Vegas story.*

**NBS-GCR-82-383;** 1982 March. 39-45. Wilson, R. *Fire protection strategies.*

**NBS-GCR-82-383;** 1982 March. 46-48. Favro, P. *Implications to fire services.*

**NBS-GCR-82-383;** 1982 March. 59-61. Nicodemus, C. *A case study.*

**NBS-GCR-82-383;** 1982 March. 62-63. Weber, J. *Implications for Federal buildings—Safe environments—What does it take?*

**NBS-GCR-82-383;** 1982 March. 64-65. Waldman, P. *Mental disabilities.*

**NBS-GCR-82-383;** 1982 March. 66-71. Gangnes, A. *Developmental disabilities.*

**NBS-GCR-82-383;** 1982 March. 72-73. Lynch, R. *Compliance.*

**NBS-GCR-82-384.** Lefkovits, H. C., (NBS contact: J. Newton). *Issue paper on entity types and relationships (for a Data Dictionary System).* 1981 August. 9 p. Available from: NTIS; PB 82-200403.

**Key words:** computer program; database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; software.

The specification for the Federal Information Processing Standard Data Dictionary System (FIPS DDS), under development by the Institute for Computer Sciences and Technology is envisioned to consist of a basic or 'core' module, with a set of optional modules containing advanced features. This report presents a proposed set of entities, relationships and attributes for inclusion in the core module of the FIPS DDS. A subset of the extensibility facility, called derivation, is recommended for the core standard, together with attribute-type extensibility. Optional module facilities are also mentioned.

**NBS-GCR-82-385.** Lefkovits, H. C., (NBS contact: J. Newton). *Issue paper on interactive language characteristics (for a Data Dictionary System).* 1981 August. 5 p. Available from: NTIS; PB 82-212739.

**Key words:** computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software.

The functional specification for the Federal Information Processing Standard Data Dictionary System (FIPS DDS) is under development by the Institute for Computer Sciences and Technology. This paper presents some considerations concerning the interactive language of the FIPS DDS. The major recommendation is that the DDS should include a single, unified interactive command language; such features as menu selection, fill-in-blank mode and command mode, will be integrated into the language. Further recommendations are that the language should be hierarchical in structure, that commands should be structurally simple and include incremented reversibility.



**NBS-GCR-82-386.** Plagman, B. Technical issue paper on entity types and relationships (for a Data Dictionary System). 1981 August. 25 p. Available from: NTIS; PB 82-203688.

Key words: computer program; database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; software.

The specification for the Federal Information Processing Standard Data Dictionary System (FIPS DDS) under development by the Institute for Computer Sciences and Technology is envisioned to consist of a basic or 'core' module, with a set of optional modules containing advanced features. This report presents a proposed set of entities, relationships and attributes for inclusion in the core module of the FIPS DDS. Full extensibility is recommended for inclusion in the core module.

**NBS-GCR-82-387.** Plagman, B. Technical issue paper on interactive language characteristics for a Data Dictionary System. 1981 August. 12 p. Available from: NTIS; PB 82-203696.

Key words: computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software.

The Functional Specification for the Federal Information Processing Standard Data Dictionary System (FIPS DDS) is under development by the Institute for Computer Sciences and Technology. This paper presents some considerations concerning the interactive language of the system. The features and functions of the language are presented from the perspectives of four different types of DDS user. Requirements for specific functions are developed using each user's needs. A discussion of possible forms of the interactive language is included.

**NBS-GCR-82-388.** Ray, S. R. Flame spread over solid fuels. 1982 April. 224 p. Available from: NTIS; PB 82-206475.

Key words: Damkohler number; flame spread; gas phase; heat transfer; laminar flame; Laser Doppler Velocimeter; opposed flow; solid fuel.

An experimental investigation of the flame spread process over solid fuels using a Laser Doppler Velocimeter (LDV) to provide two dimensional velocity measurements near the flame and the fuel surface; and thermocouple probes and radiometers were used to develop a more complete picture of the interactions of the fluid flow, heat transfer and species transport near a spreading flame. Flames spread against low opposed flows and/or high oxygen concentrations are controlled by heat transfer effects.

At higher opposed flows and/or lower oxygen concentrations, gas phase chemistry effects begin to dominate. It is believed that the fuel is vaporized behind the flame front, followed by diffusion upstream within the quench layer next to the fuel surface. The process results in a decrease in flame spread rate with opposed flow velocity and leads eventually to extinction.

A correlation of a wide range of flame spread results is presented based on two dimensionless parameters: a Damkohler number which addressed the gas phase phenomena and a dimensionless spread rate which incorporated the heat transfer effects. The correlation was successful for both thermally thick and thin fuels.

**NBS-GCR-82-389.** Chen, P. P.; Chung, I.; Perry, D. Survey of state-of-the-art logical database design tools. 1982 April. 92 p. Available from: NTIS; PB 82-209735.

Key words: database design; database design tools; database management; logical database design; logical database design tools; schema design.

This document presents the results of a survey of the state-of-the-art logical database design tools. Database design tools which are related to requirements analysis and physical database design are not included in this report. These survey results are based upon literature (published or unpublished documents) currently available.

The survey results are presented in a format that includes the names of the developers, their addresses, the characteristics of the tools, references, etc. Only those tools deemed most representative of their type have been included in this document.

**NBS-GCR-82-390.** Chen, P. P.; Chung, I.; Perry, D. A logical database design framework. 1982 April. 258 p. Available from: NTIS; PB 82-203316.

Key words: database design; database management; database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; schema design.

This report presents a methodology to be used for logical database design. The report covers the entire spectrum of the logical database design process.

The logical database design process is broken down into five major tasks: requirements analysis, global information modeling, conceptual schema design, local information modeling, and the translation of the conceptual schema into schemas for commercial DBMSs (e.g., relational, hierarchical, and network schemas). For each task of logical database design, the following information is included: a. Major sub-tasks and considerations required by that task; b. Techniques/tools which are useful in carrying out the task; c. Personnel required by the task; d. Organization structure of the project team assigned to the task; e. User involvement and authorization process for the task; f. Expected inputs and output of the task; g. Guidelines for input data collection and output data generation; h. Role of the database director in the task (for some tasks).

The major objective of this report has been to propose a concrete methodology of logical database design, not just give a list of appropriate techniques. In order to achieve this goal, the strategy was to incorporate various database design tools, techniques, and frameworks into this methodology in a coherent and consistent manner.

**NBS-GCR-82-393.** Sherman, S.; Werth, J. Relationship between database systems and operating system capabilities—Stage one—The survey. 1982 March 25. 52 p. Available from: NTIS; PB 82-238932.

Key words: database management; databases; database system features; database systems; operating system capabilities; operating systems.

In our final report, we examine seven database systems; IDMS, BDMS, RIM, ADABAS, FRAMIS, PASCAL/R and INGRES to determine relationships among their functional capabilities or features and their operating system requirements. We discuss each database system individually. We then rank the capabilities of the database systems using thirty-eight (38) functional components. The operating system requests for each database system will be discussed and the association between operating systems requests and database system features will be noted.

The views and conclusions are those of the authors and do not necessarily represent the official policies of the Department of Commerce or the United States Government.

**NBS-GCR-82-394.** Radon Subcommittee, Committee on Radiation Measurements. A survey of radon measurement needs and activities in state radiation control programs. 1982 July. 50 p. Available from: NTIS; PB 82-258930.

Key words: calibration; measurements; radiation; radon; radon progeny; standards; states; thoron.

This report summarizes the findings of a survey which was conducted in April-May, 1981 to determine radon measurement needs and present activities in state radiation control programs. The survey focuses on a wide variety of methods for measurements of radon and related quantities. This includes methods for measurement of radon ( $^{222}\text{Rn}$ ) concentration in air, potential alpha energy concentration, individual radon progeny concentrations, radon exhalation or flux density from surfaces, radon concentration in water, and thoron ( $^{220}\text{Rn}$ ) or thoron progeny concentrations in air. The report identifies the sources of radon and thoron which necessitate measurements in the states; the types of measurements and measurement methods that are performed routinely, or that the states would like to obtain or improve the capability of performing; existing calibration capabilities for these measurement methods; and the perceived needs for improving the quality of the measurements.



**NBS-GCR-82-395.** Tewarson, A. **Quantification of fire properties of fuels and interaction with fire environments.** 1982 June. 37 p. Available from: NTIS; PB 82-238452.

Key words: fires; fire size; fuels; heat of combustion; heat release rate; plastics; ventilation.

Concepts for the quantification of fire properties of fuels and interaction with fire environments are presented. It is shown that certain fire properties, i.e., actual heat of combustion and yield of fire products, are independent of fire size as long as the fire remains overventilated. Small-scale measurements of asymptotic values of generation rates of fuel vapors and fire products, per unit area of fuel, obtained by oxygen enrichment, are shown to agree reasonably well with the generation rates measured directly on a large scale in ambient air.

**NBS-GCR-82-396.** Borgeson, R. A. **Flame spread and spread limits.** 1982 July. 57 p. Available from: NTIS; PB 82-258724.

Key words: additives; computer models; flame spread; pyrolysis; solid fuels.

The computer model of Frey and T'ien (1979) has been extended to study the effects of the initial bulk fuel temperature and an inert additive. The theory assumes a thermally thin solid in an opposed flow with negligible forward heat conduction in the fuel. Raising the initial fuel temperature was found to increase the flame spread rate by augmenting the fuel mass flux in the forward part of the pyrolysis zone. As the initial fuel temperature increases, the limiting value of the Damkohler number for extinction decreases. An inert additive reduces the spread rate by lowering the flame temperature and wasting energy in the inert pyrolysis. The effect of the inert additive's pyrolysis kinetic parameters was found to be small. The flame spread rate is roughly correlatable to the fraction of energy entering the solid which is expended in the inert pyrolysis,  $Q_i/Q_T$ . As  $Q_i/Q_T$  increases, extinction occurs at a higher Damkohler number.

**NBS-GCR-82-397.** Cremeans, A. H.; Hedden, R. E. **Thermal performance case studies for residential solar heating and cooling systems.** 1982 July. 165 p. Available from: NTIS; PB 82-260100.

Key words: active solar; evaluation process; hot water; passive solar; performance criteria; solar energy; thermal performance.

This document presents five case studies on thermal performance of selected solar system designs which served as a vehicle for examining the applicability of the "Draft" Performance Criteria for Solar Heating and Cooling Systems in Residential Buildings. The purpose of this document was to identify shortcomings in the draft version of the performance criteria by means of attempting to implement the criteria. Those aspects of the criteria that require revision were highlighted.

To accomplish the intended end, an engineer who was not involved with the formulation of the criteria was chosen to apply the criteria to a variety of solar energy systems. The lack of familiarity with the criteria was intended to test the ability of the criteria to be implemented by others. A variety of systems were considered since it was clear that all criteria would not be covered by a single system evaluation. Each system evaluation is presented individually in this document.

The result of this endeavor is a methodology of applying the criteria and a set of suggestions for improvements to the thermal chapter of the Performance Criteria. The methodology is explained and then applied for each criterion. Suggestions for criteria improvement are made at the end of each criterion evaluation and summarized at the end of the document.

**NBS-GCR-82-398.** Lindler, K. W. **National Bureau of Standards passive solar test building handbook.** 1982 August. 55 p. Available from: NTIS; PB 82-265380.

Key words: cross-section; description; passive; physical; property; sensor; solar test building.

The National Bureau of Standards Passive Solar Test Building was constructed for the class A Passive Solar Program of the U.S. Department of Energy. The Test Building is located in Gaithersburg,

Maryland (39.0°N latitude, 77.3°W longitude) at an elevation of 417 ft.

The handbook provides a complete physical description of the building including floor plans and dimensions, structure, wall cross-sections, and material properties. The location of various sensors installed in and around the building is also provided.

**NBS-GCR-82-399.** Alleman, J. E.; Milke, J. A.; Hickey, H. E. **An investigation of the water quality and condition of pipe in existing automatic sprinkler systems for the analysis of design options with residential sprinkler systems.** 1982 August. 92 p. Available from: NTIS; PB 83-100263.

Key words: corrosion; friction reduction; pipes; potable water; pressure reduction; residential buildings; sprinkler systems; water.

The objectives of this study were 1) to investigate the potential effect of backflow of sprinkler water into potable water; and 2) to investigate the potential severity of the pressure reduction due to tuberculation in pipes in residential sprinkler systems.

The first objective was achieved by physical, chemical and biological analyses of water samples extracted from existing automatic sprinkler systems. The latter objective was accomplished by calculating the Hazen-Williams 'C' coefficient associated with a measured water flow rate and pressure differential along a sprinkler pipe. Specific sprinkler systems and locations for sampling were selected to provide a wide variety of conditions for the project relative to the study of parameters of pipe material, age, size, and network configuration.

In particular, this study attempts to compare the quality of water in sprinkler system pipes with that from the potable water supply for the building. The detailed analyses allow relevant and significant comparisons to be conducted to potentially assess the necessity for backflow prevention in residential sprinkler systems. Comparison of the calculated Hazen-Williams coefficient with the coefficient associated with new pipe facilitates an approximation of the degree of tuberculation in the pipe. This result provides information to assess the severity of pressure reduction as a function of time as affected by the tuberculation and thus to address the useful life of the pipe.

**NBS-GCR-82-400.** Division of Purchasing, Department of Administration, State of Colorado. **The bid-modifier as an aid to recycling.** 1982 August. 51 p. Available from: NTIS; PB 82-101816.

Key words: bid-modifier; disposal costs; PAR factor; procurement; purchasing; recovered/recycled materials; resource recovery.

This study was designed to examine the possibility of using a bid-modifier to represent disposal costs, so that the purchase of recycled/recyclable materials might be encouraged.

This study addressed a scheme designed to adjust bids received for a commodity. A factor called the Purchasing Adjustment for Recycling (PAR) was developed based on the examination of the following factors: (1) the two most common disposal systems (landfilling, and incineration), (2) the data from a literary search, (3) a simulation of the bid/award process using prior purchasing records, and (4) discussions with purchasing personnel about the problems and attitudes that could effect the use of a PAR factor in bid evaluation.

The findings and recommendations provided in this study are expected to be of value to both public and private sectors of the nation.

**NBS-GCR-82-401.** Wilson, R. G.; Weglein, R. D. **Reflection acoustic microscopy.** 1982 October. 186 p. Available from: NTIS; PB 83-139832.

Key words: acoustic material signatures; acoustic microscopy; scanning acoustic microscopy; semiconductor devices and integrated circuit inspection.

A developmental model of a pulsed reflection acoustic microscope was built, and techniques of nondestructive evaluation of surfaces and thin layered structures were studied. The image signal was enhanced 18 dB by the application of a quarter-wave acoustic antireflection coating to the surface of the lens. Many integrated circuits and device structures were studied in the scanning mode, leading to acoustic micrographs. Comparisons were made with optical and scanning electron micrographs. A static mode of operation was discovered and developed that allows us to obtain acoustic material signatures. This static mode of operation is expected to find useful applications in the



future in material analysis and thin layer thickness measurement and control.

**NBS-GCR-82-402.** Cetegen, B. M.; Zukoski, E. E.; Kubota, T. **Entrainment and flame geometry of fire plumes.** 1982 August. 203 p. Available from: NTIS; PB 83-107847.

Key words: ceilings; diffusion flames; entrainment; fire plumes; flame size; flame structure; room fires.

This study concerns the flame structure and fire plume entrainment of natural gas diffusion flames on 0.10, 0.19 and 0.50 m diameter burners. The heat release rates ranged from 10 kW to 200 kW. Entrainment measurements spanned heights starting very close to the burner surface to distances about six times the average flame heights. Finally, a theoretical study of a steady, buoyant, diffusion flame indicated the importance of the puffing in the entrainment process.

**NBS-GCR-82-403.** Brauman, S. K.; Chen, I. J. **Polymer degradation during combustion.** 1982 September. 38 p. Available from: NTIS; PB 83-110015.

Key words: combustion; degradation; polymers; polystyrene; pyrolysis; radiation flux.

The steady-state degradation and gasification of polystyrene was examined by a driven-rod radiant pyrolysis technique. The impinging radiation flux (5.6 watts/cm<sup>2</sup>) produced the same surface regression rate (0.06 cm/min) as was observed for the rods burning in air. The temperature profile in the regressing rod was measured by a fine thermocouple (0.13 mm junction) and the result used in conjunction with isothermal degradation kinetics to predict the rate of polystyrene gasification. The predicted rate is about 65% of the observed rate for the case of a nitrogen atmosphere. Other experiments include an examination of the effect of oxygen in the ambient gas and measurements of the molecular weight distribution in the degraded rods. It is concluded that the degradation mechanism for polystyrene is substantially unchanged in going from isothermal pyrolysis to combustion conditions.

**NBS-GCR-82-404.** Delichatsios, M. A.; Alpert, R. L.; Orloff, L.; Mathews, M. K. **Computer modeling of aircraft cabin fire phenomena.** 1982 October. 74 p. Available from: NTIS; PB 83-11891.

Key words: aircraft compartments; aircraft fires; ceilings; compartment fires; computer programs; fire growth; fire models; heat flux; mathematical models; walls.

A two-layer integral model is presented for the calculation of turbulent wall flows on a vertical wall including a burning wall. The turbulent flow is divided into inner and outer turbulent regimes. These regimes are matched on a dividing streamline after appropriate wall laws for the turbulent flow have been developed. Wall laws, which depend on the specific boundary conditions, are proposed for an adiabatic wall plume, an adiabatic wall plume with addition of an inert material at the wall and a burning wall. The present methodology could be used also to develop wall flow laws for a constant temperature or constant heat flux wall and the overfire region above a burning wall. Numerical results are presented for an adiabatic wall flow with constant buoyancy flux and a burning wall without appreciable radiation. The common constants in both cases are the same. The agreement with existing experimental results in both cases is excellent. Additional detailed experiments on turbulent wall fires are planned to verify all the predictions of the present model. The turbulent wall model for a burning wall can readily be extended to include radiation.

**NBS-GCR-82-405.** DenUyl, R. B.; VanPoperin, N.; Whitehill, D.; Winter, A.; Alsager, P.; Deline, M.; Hall, J.; McGrath, W.; Strader, R. **Hazardous waste management in the Great Lakes region: Opportunities for economic development and resource recovery.** 1982 September 30. 428 p. Available from: NTIS; PB 83-119909.

Key words: electroplating; Great Lakes region; hazardous waste management; paint manufacturing; resource recovery; solvent recovery; steel manufacturing.

The purpose of this study is to develop methodologies that evaluate the economic impacts associated with hazardous waste management

costs and to assess the economic potential of resource recovery. The study concentrates on the states of the Great Lakes region. Two models were developed; one for the electroplating industry and the other analyzing options for solvent recovery. Both models were based on constrained economic optimization methodology. The computer model analyzing the electroplating industry compared the cost of five alternative treatment and resource recovery technologies for 24 electroplating shops in the Great Lakes region. A sensitivity analysis of the results of the electroplating model was conducted to determine what kind of financial incentives would induce greater adoption of resource recovery technologies. The model analyzing the economics of solvent recovery compared the cost of off-site disposal or incineration with off-site recovery of waste solvents and with recovery at the plant site. In order to determine the economic impact of hazardous waste management costs, a computer program for a financial impact model was developed. The study also developed a methodology to predict whether companies that generate hazardous wastes would be likely to relocate closer to treatment and disposal facilities to reduce transportation and disposal costs.

**NBS-GCR-82-407.** Gillan, M. **Short-term creep of concrete at elevated temperatures.** 1982 September. 112 p. Available from: NTIS; PB 83-118117.

Key words: aggregates; concretes; creep tests; fire tests; high temperature tests.

Two hundred thirty-one creep strain tests were conducted at temperatures from ambient to 1200F over periods from 6 to 24 hours on 2x4-in cylindrical concrete specimens. In addition, forty-five compressive strength tests were conducted on heated concrete specimens.

Test variables included load (0.30, 0.45, and 0.60 f<sub>c</sub>), temperature (73 to 1200F), rate of heating (0 and 10F/min.), length of heating (6 and 24 hr), aggregate type (calcareous, siliceous, and lightweight), variation of compressive strength with temperature, and concrete relative humidity (0, 50, and 100% RH).

A model of short-term creep of concrete at elevated temperatures as a function of significant test variables was developed.

**NBS-GCR-82-408.** Groner, N. E. **A matter of time—A comprehensive guide to fire emergency planning for board and care homes.** 1982 November. 117 p. Available from: NTIS; PB 83-139345.

Key words: board and care homes; developmentally disabled; elderly persons; evacuation; fire emergency planning; fire protection; group homes; mental disorders.

This manual, written in plain English, advises persons concerned about planning for fire emergencies in board and care homes. Because board and care homes encompass a wide variety of facilities, the manual does not suggest any single plan, but rather instructs operators how to tailor plans to the circumstances in particular board and care homes. The "principle of the safety margin" is used to organize all the contents of the manual. The manual includes exercises designed to select the most appropriate combinations of escape and refuge strategies for particular facilities, and how to anticipate the assistance needs of residents in a fire emergency. Also included are nontechnical descriptions of fire protection techniques appropriate to board and care homes, specific suggestions for training staff and residents using three types of fire drills, and advice about how to motivate staff and residents and how staff and residents should react when a fire is suspected or discovered. Finally, appendices provide step-by-step guides for writing emergency procedures for individuals or groups of both residents and staff, as well as a list of resources where interested persons can seek further help.

**NBS-GCR-82-409.** Weston-Black & Veatch. **Feasibility study for resource recovery: Southwest Brooklyn Incinerator.** 1982 September. 305 p. Available from: NTIS; PB 83-119503.

Key words: destruct heating; electricity production; energy recovery; incineration; New York City; resource recovery; solid waste management; steam production.

The primary purpose of this investigation was to examine both the technical and economic feasibility of exploiting the heating value of the refuse and the material value of the incinerator ash processed at the Southwest Brooklyn Incinerator. Based on the results of field testing, the combustion of municipal refuse at Southwest Brooklyn



would be capable of generating 2.2 trillion Btu of energy annually. On the basis of the examination of both the technical requirements and the economics of recovering energy and materials from processed refuse presented in this report, the following conclusions were drawn: (1) the recovery of energy for electricity generation and/or electricity generation with steam production for district heating during the winter months is both technically and economically feasible, and appropriate action should be taken as soon as practical to plan for the preparation of construction contract documents for such an undertaking; and (2) there exists an opportunity in the City of New York for the recovery of incinerator ash for use as asphalt aggregate in City-owned asphalt production facilities in Brooklyn. Further testing is required to verify the full potential of ash utilization. A detailed review of potential corrosion problems, and mitigating measures, as well as the expected waste heat boiler operational life, was undertaken to determine process modifications and equipment requirements to minimize the impact of corrosion on heat recovery operation. A market survey of potential energy users within a three-quarter mile radius of the incinerator was implemented to determine the available steam market.

**NBS-GCR-82-413.** Johnson, T. L.; Milligan, S. D.; Fortmann, T. E. *Hierarchical Control System Emulation User's Manual*. 1982 October. 128 p. Available from: NTIS; PB 83-141945.

Key words: automated manufacturing; automatic control; computer-aided design; computer-aided manufacturing; hierarchical control systems; simulation.

The Hierarchical Control System Emulation is a collection of computer programs written in the high-level Praxis language for use on a Digital Equipment Company VAX 11/780<sup>TM</sup> processor under the VMS<sup>TM</sup> operating system. These programs allow the user to write, debug, and concurrently emulate modules of a hierarchical control system and to simulate the physical plant which is controlled. The emulation executes in real time and interactive display and data logging capabilities are included. The emulation is intended as a computer-aided control system design tool for the NBS Automated Manufacturing Research Facility. The User's Manual describes the use of the emulation and provides necessary theoretical background; it is not application-specific.

**NBS-GCR-82-414.** Milligan, S. D.; Johnson, T. L. *Hierarchical Control System Emulation Programmer's Manual*. 1982 October. 36 p. Available from: NTIS; PB 83-137059.

Key words: automated manufacturing; automatic control; computer-aided design; computer-aided manufacturing simulation; hierarchical control systems.

The Hierarchical Control System Emulation is a collection of computer programs written in the high-level Praxis language for use on a Digital Equipment Company VAX 11/780<sup>TM</sup> processor under the VMS<sup>TM</sup> operating system. These programs allow the user to write, debug, and concurrently emulate modules of a hierarchical control system and to simulate the physical plant which is controlled. The emulation executes in real time and interactive display and data logging capabilities are included. The emulation is intended as a computer-aided control system design tool for the NBS Automated Manufacturing Research Facility. The Programmer's Manual provides documentation of the design of the emulation code and the emulation programs themselves; it is intended for the system programmer rather than the user.

**NBS-GCR-ETIP 82-99.** Clarren, S.; Nalley, P.; Zuiches, C. *The experiment in post-marketing surveillance of prescription drugs: An initial status report*. 1982 November. 190 p. Available from: NTIS; PB 83-132332.

Key words: drug development; drug regulation; innovation; post-marketing surveillance; regulatory experiments.

This study examines baseline information on the continuing administrative experiment in changes in the regulatory process for prescription drugs. The experiment deals with changes in post marketing surveillance and their impact on the drug approval process and on innovation in the drug industry and health care in general. The baseline information includes data and analysis covering effects on innovation, the Food and Drug Administration regulatory decisions and the pharmaceutical industry. The study also includes

recommendations for continuing the experiment and measuring its effects.

**NBS-GCR-ETIP 82-100.** Hebert, R.; Hoar, R., Jr. *Government and innovation: Experimenting with change (The final report of the Experimental Technology Incentives Program)*. 1982 December. 146 p. Available from: NTIS; PB 83-134486.

Key words: administrative experiments; economic assistance; innovation; procurement; regulation; research and development; technology policy.

This final report of the Experimental Technology Incentives Program (ETIP) contains a brief history of the program, a description of the major projects and accomplishments, a listing of lessons learned and a sampling of outside views and opinions of the program's strengths and weaknesses. An appendix contains a list of all projects (numbered sequentially) and published reports. The appendix also describes the process by which greater project detail and data can be obtained.

**U.S. Patent 4,312,224.** Domen, S. R. *Absorbed dose water calorimeter*. 26 January 1982. 8 p.

Key words: absorbed dose; adiabatic; calorimeter; polyethylene film; thermistor; water calorimeter.

An absorbed dose water calorimeter that takes advantage of the low thermal diffusivity of water and the water-imperviousness of polyethylene film. An ultrasmall bead thermistor is sandwiched between two thin polyethylene films stretched between insulative supports in a water bath. The polyethylene films insulate the thermistor and its leads, the leads being run out from between the films in insulated sleeving and then to junctions to form a Wheatstone bridge circuit. Convection barriers may be provided to reduce the effects of convection from the point of measurement. Controlled heating of different levels in the water bath is accomplished by electrical heater circuits provided for controlling temperature drift and providing adiabatic operation of the calorimeter. The absorbed dose is determined from the known specific heat of water and the measured temperature change.

**U.S. Patent 4,314,466.** Harris, J. E. *Handcuff improvements*. 9 February 1982. 8 p.

Key words: handcuffs; triple backing.

Triple locking handcuffs are provided having a lock which has an abutment therein which pushes against a bolt in the lock to double lock the latch and triple lock the ratchet and pawl of the lock. In the triple locked position a biasing means forces the bolt against the abutment, and to unlock the handcuffs a number of different mechanical means are provided for moving the bolt slightly away from the abutment, whereupon the ordinary handcuff key can be used to unlock the handcuffs. Handcuffs are also provided which automatically double and triple lock upon application to the wrist.

**U.S. Patent 4,315,255.** Harris, R. E.; Clark, A. *Multiple-quantum interference superconducting analog-to-digital converter*. 9 February 1982. 6 p.

Key words: analog to digital converter; superconducting interferometers.

An analog-to-digital converter using superconducting interferometers connected in parallel, each interferometer being identical. The coupling of the analog signal to each successive interferometer is increased in the ratio of 1:2:4:8:16:32, etc. The application of a pulsed power supply to the parallel connected interferometer generates output voltages on the interferometers. The output voltages are a Gray Code representation of the analog signal.

**U.S. Patent 4,315,433.** Edelman, S.; Payne, B. F. *Polymer film accelerometer*. 16 February 1982. 4 p.

Key words: accelerometer; inertial mass; piezoelectric polymer films.

An accelerometer is provided which utilizes at least one sheet of piezoelectric polymer film, supported under tension in a frame, for sensing the acceleration-responsive movements of an associated



inertial mass and providing an electrical output in accordance therewith. The accelerometer preferably comprises a pair of such sheets with the inertial mass, e.g., a sphere, supported therebetween. Connections to an electrical measurement unit are made through a coaxial cable whose outer sheath and inner conductor are respectively connected to outer and inner electrodes formed by metallic coatings on the outer and inner surfaces of the sheets. The frame is preferably cylindrical and a pair of associated rings which fit within the frame serve to clamp the two sheets in place under tension.

**U.S. Patent 4,327,233.** Martinez, R. I.; Herron, J. T. Method for producing carbocyclic compounds from cyclic sulfide. 27 April 1982. 8 p.

Key words: carbocyclic compound; cyclic sulfide; ozone; vapor phase reaction.

A method is provided for producing a carbocyclic compound by contacting an organic compound containing a 4-8 membered cyclic sulfide with ozone, in the vapor phase, and recovering a product containing a 3-7 membered carbocyclic ring.

**U.S. Patent 4,331,933.** Allan, D. W.; Garvey, M. Microwave power level stabilizing circuit for cesium beam frequency standards. 25 May 1982. 8 p.

Key words: atomic clock; atomic resonance frequency error; fixed offset frequency; main atomic peak; microwave power level changes; servo; sidelobe atomic peak.

Perceived atomic resonance frequency error resulting from microwave power level changes in atomic clocks is eliminated by controlling the device's microwave power source output in response to deviations from a fixed frequency relationship between the main atomic peak and a sidelobe peak of the atomic beam frequency spectrum. This is accomplished by a microwave power control servo system that includes a time sharing interrogation circuit for detecting and monitoring the frequencies of the main atomic peak and the sidelobe peak and a comparator that compares the frequencies of the main atomic and sidelobe peaks and generates a feedback control signal in response to frequency differences between the two that deviate from a fixed difference frequency. The feedback signal is used to control the microwave power source output in a manner that constrains the main atomic peak and the sidelobe peak at a fixed offset frequency.

**U.S. Patent 4,351,810.** Martinez, R. I.; Herron, J. T. Method for removing sulfur dioxide from a gas stream. 28 September 1982. 10 p.

Key words: gas phase reaction; stabilized Criegee intermediate; sulfur dioxide removal.

A method is provided for removing  $\text{SO}_2$  from gas streams by its gas-phase reaction with a stabilized Criegee intermediate under conditions where a very large excess of water vapor is avoided, resulting in efficient scavenging of  $\text{SO}_2$  by the Criegee intermediate to form an adduct. The adduct reacts with water vapor to convert it directly to sulfuric acid, which is then separated from the gas stream. The Criegee intermediate may be generated in a variety of ways.

**U.S. Patent 4,361,630.** Johnson, C. E., Sr. Ultra-black coating due to surface morphology. 30 November 1982. 7 p.

Key words: electroless nickel plating; nickel-phosphorus alloy; ultra-black coating.

The invention provides a method of producing an ultra-black surface coating, having an extremely high light absorption capacity, on a substrate, such as a metal, ceramic, glass, or plastic, the blackness being associated with a unique surface morphology consisting of a dense array of microscopic pores etched into the surface, as well as the resulting coated substrate.

The ultra-black surface, which has a spectral reflectance on the order of about from 0.5 to 1.0% at wavelengths of light of about from 320 to 2140 nanometers, finds use as a solar collector in the field of solar energy.



## 6. TITLES AND ABSTRACTS OF PAPERS PUBLISHED IN NON-NBS MEDIA

**20775.** Clarke, F. B.; Birky, M. M. Fire safety in dwellings and public buildings, *Bull. N.Y. Acad. Med.* 57, No. 10, 1047-1060 (Dec. 1981).

Key words: cigarettes; codes; escape; fatalities; fire; flaming; flashover; nonresidential; residential; scenario; smoldering.

Some of the principal factors in building fire safety are reviewed. The most important factors are: 1. Fatal fires occur almost exclusively in buildings, the great majority in residences; 2. The building serves to catch and hold combustion products, inhalation of which is the actual cause of death; 3. Most fatal building fires involve the burning of the contents, rather than the structure itself—these contents are increasingly of synthetic materials; 4. Improved technology is now available, both for making furnishings resistant to small ignition sources and for suppressing residential fires; 5. Smoke detectors are now widely used in homes, with some positive effect being observed in national fire experience; 6. Most code enforcement focuses on relatively large buildings (i.e., those other than one and two family homes), and the fire safety record of these structures is comparatively good; 7. Seldom is as much attention paid to the fire properties of common building contents, and it is evolutionary changes in these, as well as unforeseen characteristics of building occupants, which is a major challenge to building regulation; 8. New building designs and materials put great demands on the adaptability of code requirements, leading to increased demands for equivalency systems.

**20776.** Saloman, E. B.; Ebner, S. C.; Hughey, L. R. Radiometry using synchrotron radiation, *SPIE* 279, 76-83 (1981).

Key words: detector calibrations; electron storage rings; electron synchrotrons; synchrotron radiation.

Synchrotron radiation is a source of continuum radiation ranging from the x-ray or soft x-ray region (depending on machine energy) to beyond the visible region. The amount of radiation emitted is a calculable function of machine operating parameters. This makes it possible to use synchrotron radiation from electron synchrotrons and electron storage rings as an absolute source particularly in the VUV and soft x-ray regions where other standards are difficult to find. At the National Bureau of Standards (NBS) an electron storage ring (SURF-II) has been used to calibrate spectrometers and photometers used in solar and aeronomy research and in fusion plasma diagnostics. A large chamber has recently been completed to facilitate such calibrations. The radiation incident on these spectrometers can be calculated to uncertainties of 3%. A technique to exactly determine the number of electrons orbiting in the ring is currently being developed to reduce this uncertainty. Detector calibrations between 5–55 nm are routinely carried out at SURF-II and transfer standard detectors with 6–10% uncertainties over the range of 5–254 nm are supplied. Special studies of "practical," high efficiency, and disposable photodiodes have been made by NBS in collaboration with other groups.

**20777.** Deprit, A. Delaunay normalisations, *Celest. Mech.* 26, 9-21 (1982).

Key words: algebra by computer; Birkhoff normalisation; celestial mechanics; resonances; satellite theory.

Too many terms are generated by a Delaunay normalisation when the perturbation is developed in powers of the eccentricity. Ways of bypassing the expansion are discussed. There are: (i) Brouwer's method of implicit variables; (ii) the preparation by canonical transformations; and (iii) the application of representation theory for Lie algebras. Illustrations of the techniques are drawn from the main problem of satellite theory and from the (1-1) resonance at the triangular equilibrium in the restricted problem of three bodies.

**20778.** O'Leary, D. P.; Simmons, J. A. A bidiagonalization-regularization procedure for large scale discretizations of ill-posed problems, *SIAM J. Sci. Stat. Comput.* 2, No. 4, 474-489 (Dec. 1981).

Key words: first kind integral equation; ill-posed problems; Lanczos algorithm; regularization.

In this paper, we consider ill-posed problems which discretize to linear least squares problems with matrices  $K$  of high dimensions. The

algorithm proposed uses  $K$  only as an operator and does not need to explicitly store or modify it. A method related to one of Lanczos is used to project the problem onto a subspace for which  $K$  is bidiagonal. It is then an easy matter to solve the projected problem by standard regularization techniques. These ideas are illustrated with some integral equations of the first kind with convolution kernels, and sample numerical results are given.

**20779.** Boisvert, R. F. Families of high order accurate discretizations of some elliptic problems, *SIAM J. Sci. Stat. Comput.* 2, No. 3, 268-284 (Sept. 1981).

Key words: elliptic partial differential equations; finite difference methods; high order accuracy; Poisson equation.

In this paper we construct and analyze high order finite difference discretizations of a class of elliptic partial differential equations. In particular, two one-parameter families of fourth order HODIE discretizations of the Helmholtz equation are derived and a discretization optimal with respect to a certain norm of the truncation error is identified. The use of compact nine-point formulas of positive type admits both fast direct methods and standard iterative methods for the solution of the resulting systems of linear equations. Extensions yielding sixth order accuracy for the Helmholtz equation and fourth order accuracy for a more general operator are given. Finally, numerical results demonstrating the effectiveness of the discretizations for a wide range of problems are presented.

**20780.** Laufer, A. H. Reactions of ethynyl radicals. Rate constants with  $\text{CH}_4$ ,  $\text{C}_2\text{H}_6$ , and  $\text{C}_2\text{D}_6$ , *J. Phys. Chem.* 85, No. 25, 3828-3831 (Dec. 10, 1981).

Key words: abstraction; ethane; ethane-d<sub>6</sub>; ethynyl radicals; rate constants.

The rate constants for the abstraction of H atoms from  $\text{CH}_4$ ,  $\text{C}_2\text{H}_6$ , and D atoms from  $\text{C}_2\text{D}_6$  by  $\text{C}_2\text{H}$ (ethynyl) radicals have been determined by using a flash photolysis-kinetic spectroscopic technique. The values obtained, at 297 K, are  $(1.2 \pm 0.2) \times 10^{-12}$ ,  $(6.5 \pm 0.4) \times 10^{-12}$ , and  $(3.1 \pm 0.5) \times 10^{-12} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ , respectively. The rate constants are independent of added helium over the pressure range 20–700 torr. The kinetic parameters were determined by monitoring the acetylene product spectroscopically using  $\text{C}_2\text{H-CF}_3$  as the source of ethynyl radicals.

**20781.** Brown, R. L.; Laufer, A. H. Calculation of activation energies for hydrogen-atom abstractions by radicals containing carbon triple bonds, *J. Phys. Chem.* 85, No. 25, 3826-3828 (Dec. 10, 1981).

Key words: abstraction reactions; activation energies; bond-energy-bond-order; CN; ethynyl; radicals.

Activation energies are calculated by the bond-energy-bond-order (BEBO) and the bond-strength-bond-length (BSBL) methods for the reactions of  $\text{C}_2\text{H}$  radicals with  $\text{H}_2$ ,  $\text{CH}_4$ , and  $\text{C}_2\text{H}_6$  and for the reactions of CN radicals with  $\text{H}_2$  and  $\text{CH}_4$ . The BSBL technique accurately predicts the activation energies for these reactions while the BEBO method yields energies averaging 9 kcal higher than those observed. A possible reason for the disagreement is considered.

**20782.** Maki, A. G.; Sams, R. L. High temperature, high resolution infrared spectral measurements on the HNC-HCN equilibrium system, *J. Chem. Phys.* 75, No. 9, 4178-4182 (Nov. 1, 1981).

Key words: absorption; high temperature; hydrogen isocyanide; infrared; molecular structure; potential functions; spectroscopy.

Spectral measurements have been made on HNC in equilibrium with HCN at temperatures ranging from 900 to 1250 K. From measurements of absorption intensity vs temperature it is determined that the ground state of HNC is  $10.3 \pm 1.1 \text{ kcal/mol}$  ( $43.1 \pm 4.6 \text{ kJ/mol}$ ) above the ground state of HCN. High resolution data are given on the following vibrational transitions for HNC near  $3650 \text{ cm}^{-1}$ :  $10^0-00^0$ ,  $11^1-01^1$ ,  $12^0-02^0$ , and  $12^0-02^0$ . Measurements near  $2780 \text{ cm}^{-1}$  are also given for the  $10^0-00^0$  and  $11^1-01^1$  transitions for DNC. Aside from the low bending force constant, these measurements show nothing unusual about the bending potential function.



**20783.** Laufer, A. H. The formation of the vinylidene radical as an intermediate in the combination of triplet methylene, *J. Chem. Phys.* **76**, No. 2, 945-948 (Jan. 15, 1982).

Key words: energetics; excited states; kinetics; methylene; radicals; vinylidene.

The vinylidene radical ( $\text{H}_2\text{C}=\text{C}$ ) is proposed as an intermediate in the combination reaction of triplet methylene. The conclusion is based upon the distribution of isotopic acetylenes produced from a 1:1 mixture of  $\text{CD}_2$  and  $\text{CH}_2$ . The path of the reaction and the energetics of the intermediate species are discussed.

**20784.** Weisshaar, J. C.; Zwier, T. S.; Leone, S. R. Nascent product vibrational state distributions of ion-molecule reactions: The proton transfer reactions  $\text{F} + \text{HX} \rightarrow \text{HF}(\nu) + \text{X}^+$ ,  $\text{X} = \text{Cl}, \text{Br}, \text{and I}$ , *J. Chem. Phys.* **75**, No. 10, 4873-4884 (Nov. 15, 1981).

Key words: flowing afterglow; fluoride ion; infrared chemiluminescence; ion-molecule reactions; vibration product states.

Nascent vibrational state distributions are obtained for the HF products of the proton transfer reactions  $\text{F} + \text{HX} \rightarrow \text{HF}(\nu) + \text{X}^+$ ,  $\text{X} = \text{Cl}, \text{Br}, \text{and I}$ . The reactions are carried out in a flowing afterglow apparatus in which the reagents are fully thermalized (300 K). The product states are measured by low resolution infrared chemiluminescence spectra obtained with a Ge:Cu infrared detector and a circular variable filter. The nascent  $\text{HF}(\nu)$  distributions are as follows: for  $\text{F} + \text{HCl}$ ,  $N_1:N_2:N_3=0.46:0.33:0.21$ ; for  $\text{F} + \text{HBr}$ ,  $N_1:N_2:N_3:N_4=0.28:0.27:0.24:0.21$ ; for  $\text{F} + \text{HI}$ ,  $N_1:N_2:N_3:N_4:N_5=0.20:0.23:0.22:0.20:0.15$ . All three reactions channel the available exothermicity quite efficiently into product vibration. Product rotational state information cannot be obtained due to collisions with the He carrier gas. In spite of the deep attractive wells of the  $\text{F} + \text{HX}$  potential energy surfaces, in all three cases the degree of vibrational excitation in the ion-molecule reaction is remarkably similar to, although distinctly smaller than, that of the corresponding neutral  $\text{F} + \text{HX}$  reactions. The results strongly suggest that these ion-molecule reactive collisions are direct encounters and that the kinematic effect of the mass combination (transfer of a light particle between two heavy particles) dominates over the influence of the shape of the potential energy surface in determining the product vibrational state distributions.

**20785.** Pence, W. H.; Baughcum, S. L.; Leone, S. R. Laser UV photofragmentation of halogenated molecules. Selective bond dissociation and wavelength-specific quantum yields for excited  $\text{I}^2(\text{P}_{1/2})$  and  $\text{Br}^2(\text{P}_{1/2})$  atoms, *J. Phys. Chem.* **85**, No. 25, 3844-3851 (Nov. 1981).

Key words:  $\text{Br}^2(\text{P}_{1/2})$ ;  $\text{I}^2(\text{P}_{1/2})$ ; laser; photofragmentation; photolysis; ultraviolet.

Quantum yields for excited  $\text{I}^2(\text{P}_{1/2})$  and  $\text{Br}^2(\text{P}_{1/2})$  atom formation are measured for  $\text{CH}_3\text{I}$ ,  $\text{CH}_3\text{I}_2$ ,  $\text{C}_2\text{F}_3\text{I}$ ,  $\text{C}_2\text{F}_3\text{Br}$ ,  $1,2\text{-C}_2\text{F}_4\text{IBr}$ ,  $\text{CF}_3\text{Br}$ ,  $\text{C}_6\text{H}_5\text{I}$ , and  $\text{C}_6\text{H}_5\text{CH}_2\text{I}$  at selected laser wavelengths, 193, 248, 268, and 308 nm. The quantum yield results are discussed in terms of selective bond dissociation mechanisms and wavelength-specific electronic excitation and curve-crossing pathways.

**20786.** Julienne, P. S.; Mies, F. H. A multichannel distorted-wave approximation, *J. Phys. B: At. Mol. Phys.* **14**, 4335-4347 (1981).

Key words: adiabatic electronic-rotational states; atomic scattering; distorted wave approximation; fine structure transitions; Hund's coupling; WKB approximation.

A multichannel distorted-wave approximation for atom-atom scattering based on an expansion of the total diatomic wavefunction in adiabatic electronic-rotational (AER) states is studied through a numerical example involving the  $^3\text{P}_1 \rightarrow ^3\text{P}_0$  fine-structure transitions in excited Zn, Cd and Hg. The AER states are those which diagonalise the full electronic-rotational Hamiltonian continuously as a function of  $R$ . In the limit of weak interaction the coupled equations for the exact wavefunctions in the AER representation suggest a simple distorted-wave approximation. The scattering matrix element is evaluated using the single-channel radial wavefunctions obtained from the adiabatic potentials, and its magnitude depends on the  $R$  variation of the orthogonal matrix which diagonalises the complete multichannel

interaction energy.

The approximation retains the simplicity of requiring only single-channel radial functions while going beyond the Born-Oppenheimer approximation and permitting treatment of the case where the Hund's coupling case of angular momentum varies strongly in the region of inelastic coupling. It is especially useful for including the effect of distant closed channels. The approximation is shown to work well for the model considered. Furthermore, it readily lends itself to a simple second-order correction through the WKB random-phase approximation and suggests a WKB formulation of the close-coupling equations.

**20787.** Conneely, M. J.; Geltman, S. Resonance effects in multichannel free-free transitions of an electron scattering from a hydrogen atom, *J. Phys. B: At. Mol. Phys.* **14**, 4847-4864 (1981).

Key words: angular distributions; close-coupling approximation;  $\text{CO}_2$  laser; elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; free-free transitions; Nd laser; photon-assisted transitions.

We present here the results of the first detailed theoretical calculation of differential cross sections for free-free transitions which involve electrons at real target-atom scattering resonances in a laser field. The scattering resonances included, which may occur in the initial or final state (or both) of the free-free absorption, are the lowest  $^1\text{S}^e$ ,  $^1\text{P}^o$ ,  $^3\text{S}^e$  and  $^3\text{P}^o$  Feshbach resonances of hydrogen occurring at incident electron energies just below the  $n=2$  excitation threshold. We evaluate differential cross sections involving initial  $^1\text{S}^e$  and  $^3\text{P}^o$  resonances and radiation at the  $\text{CO}_2$  laser wavelength ( $\hbar\omega=0.117$  eV), the double resonances between  $^1\text{S}^e$  and  $^1\text{P}^o$  ( $\hbar\omega=0.630$  eV) and between  $^3\text{P}^o$  and  $^3\text{S}^e$  ( $\hbar\omega=0.383$  eV), and the processes going from  $^1\text{S}^e$  and  $^3\text{P}^o$  resonances to a final state above the  $n=2$  threshold by means of radiation at the Nd laser wavelength ( $\hbar\omega=1.17$  eV). The latter process has three possible final atomic states ( $1s$ ,  $2s$ ,  $2p$ ) and corresponds to the joint electron-photon excitation of the hydrogen atom. It is found that the presence of the electron scattering resonances can enhance the background free-free absorption in the forward direction by as much as four orders of magnitude, but has a relatively minor effect in the backward direction.

**20788.** Krauss, M.; Stevens, W. J. Ab initio determination of the ground-state potential energy curve for  $\text{Ar}_2$ , *Chem. Phys. Lett.* **85**, No. 4, 423-427 (Jan. 22, 1982).

Key words: damped dispersion; energy curve; polarizabilities; Van der Waals.

A totally ab initio potential energy curve for  $\text{Ar}_2$  is constructed by adding individually damped dispersion terms to an accurate single configuration self-consistent-field repulsive interaction curve. However, the well depth ( $77\text{ cm}^{-1}$ ) of our computed curve is significantly less than the experimentally deduced value ( $99.4\text{ cm}^{-1}$ ).

**20789.** Robertson, A. F. Roots and history of committee E-5, *ASTM Stand. News* **9**, No. 12, 14-20 (Dec. 1981).

Key words: ASTM E-5; fire tests; histories; test methods.

ASTM originally developed as an American Section of the International Association for Testing Materials in 1898. Committee P, on Fireproofing, was the predecessor of the present committee E-5 on Fire Test Methods. A brief narrative review is presented of the somewhat tedious development of fire test methods during the first fifty years of the committee's existence.

**20790.** Peterlin, A.; Snyder, R. G. Accordion-type laser-Raman scattering by drawn linear polyethylene, *J. Polym. Sci., Polym. Phys. Ed.* **19**, 1727-1737 (1981).

Key words: accordion-type oscillation; drawn polyethylene; gauche defect; Raman scattering; straight chain section.

One can reproduce the observed accordion-type laser-Raman (ALR) scattering of highly drawn linear polyethylene if one assumes that any gauche defect in the crystal lattice which interrupts the all-trans conformation sequence of the molecular chain completely decouples the accordion-type longitudinal oscillations of the two sections on both sides of the defect. Each oscillates independently of the rest. The length of the section, smaller than the full length of the



straight chain between the crystal surfaces, determines the frequency of the ALR absorption. One such defect per five chain stems of the ideal crystal yields a straight-length distribution which agrees sufficiently well with that derived from the ALR spectrum. Small-angle x-ray scattering very generally registers the resulting decrease of the electron density of the crystalline component without yielding more detailed information about the location and frequency of such *gauche* defects.

**20791.** Phillips, W. D. Rapid frequency scanning of ring dye lasers, *Appl. Opt.* 20, No. 22, 3826-3827 (Nov. 15, 1981).

Key words: frequency scanned laser; rapid frequency scanning; ring dye laser; single frequency dye laser; tuneable laser.

I have developed a technique for rapid frequency scanning of single frequency CW ring dye lasers. Scan rates over 60 THz/s with a range of more than 7 GHz have been achieved. Straightforward modifications of the technique should yield even larger rates and ranges.

**20792.** Kashiwagi, T. Effects of sample orientation on radiative ignition, *Combust. Flame* 44, 223-245 (1982).

Key words: absorption; CO<sub>2</sub> laser; decomposition; ignition; polymethacrylate; radiation; surface temperature; wood.

The effects of sample orientation on autoignition delay times and the minimum external radiant flux for autoignition were studied using a CO<sub>2</sub> laser and a gas fired radiant panel as external radiant sources with PMMA and red oak as samples. Ignition delay times were shorter with the horizontal sample than with the vertical one at the same external radiant flux. The minimum external radiant flux for ignition was also less with the horizontal sample. The absorption of external radiation by the boundary layer of decomposition products for the vertical orientation is significant, although its amount is less than the absorption through the plume for the horizontal orientation. Surface temperature at ignition is higher with vertical sample orientation than with horizontal at the same external radiant flux. A theoretical calculation of the surface temperature history with endothermic gasification significantly underestimates the experimental results; this raises a question of the applicability of regression rate expression derived from steady state experiments to the dynamic heating condition.

**20793.** O'Neill, J. G. Fast response sprinklers in patient room fires, *Fire Technol.* 17, No. 4, 254-274 (Nov. 1981).

Key words: clothing wardrobes; health care facilities; hospital mattresses; smoke movement; sprinkler systems.

The Center for Fire Research conducted a series of tests which examined the use of automatic sprinklers in patient room fires. The full-scale fire tests were conducted in a patient room, corridor, lobby test arrangement. The results of tests, involving mattresses and bedding as the burning items, indicated that smoke obscuration was significantly lower where simulated fast response sprinklers were used. In tests involving combustible clothing wardrobes however, the simulated fast response sprinklers did not improve overall performance compared to the results of tests with conventional fusible element sprinklers.

**20794.** Danos, M. Bohm-Aharonov effect: The quantum mechanics of the electrical transformer, *Am. J. Phys.* 50, No. 1, 64-66 (Jan. 1982).

Key words: Bohm-Aharonov; electrical transformer; interference; quantum mechanics; uncertainty relations; vector potential.

A simple physical picture is presented of the Bohm-Aharonov effect.

**20795.** Yee, K. W.; Blomquist, D. S. An on-line method of determining tool wear by time-domain analysis, *Soc. Manuf. Eng., Tech. Pap. MR82-901*, 6 pages (1982).

Key words: automated manufacturing; drill failure prediction; drill wear; finished dimensions; improper drilling; time-domain analysis; tool failure; tool wear; vibration signatures.

A method for determining drill wear and predicting drill breakage

has been implemented by applying time-domain analysis on a signal from an accelerometer mounted on the workpiece. This analysis is performed by a single-chip microcomputer. In 49 of 50 cases the system predicted the drill would fail 2 to 20 holes before actual failure. This system is currently used by the Fabrication Technology Division in the National Bureau of Standards machine shops. More than 15,000 1-mm holes have been drilled with only a single drill failure, which occurred when the system was inadvertently disabled. Fifteen drills with worn or damaged cutting edges were detected.

**20796.** Schaffer, R.; Sniegowski, L. T.; Welch, M. J.; White V, E.; Cohen, A.; Hertz, H. S.; Mandel, J.; Paule, R. C.; Svensson, L.; Björkhem, I.; Blomstrand, R. Comparison of two isotope dilution/mass spectrometric methods for determination of total serum cholesterol, *Clin. Chem.* 28, No. 1, 5-8 (1982).

Key words: cholesterol analysis; definitive method; isotope dilution/mass spectrometry; mass spectrometry; stable isotope dilution analysis; statistical analysis; total cholesterol analysis.

Isotope dilution/mass spectrometric methods for total serum cholesterol, developed separately at the Karolinska Institutet (KI) and the National Bureau of Standards (NBS), were compared by applying them to a common set of serum pools. A search for the cause of a systematic difference of a few percent in results from the two methods revealed that the KI cholesterol standard contained lathosterol, which interfered with the calibration of the method. With NBS Standard Reference Material cholesterol used for new analyses at the KI, the average difference in mean values dropped to 0.2%. The NBS results are more precise. This is attributed to the protocols NBS used for sample preparation and mass spectrometry. However, these protocols make the NBS method more complex and time-consuming. A recent critical article on the use of this technique for total cholesterol is also examined.

**20797.** Lindgren, R. A.; Plum, M. A.; Gerace, W. J.; Hicks, R. S.; Parker, B.; Peterson, G. A.; Singhal, R.; Williamson, C. F.; Maruyama, X. K.; Petrovich, F. Isospin splitting of isovector high-spin "stretched" particle-hole excitations in non-self-conjugate nuclei, *Phys. Rev. Lett.* 47, No. 18, 1266-1269 (Nov. 2, 1981).

Key words: isospin splitting; isovector; Lane model; magnetic states in nuclei.

A simple Lane model is used to parametrize the energy systematics of the isospin splitting of high-spin magnetic states in non-self-conjugate nuclei. A strength parameter  $V_1 = 106 \pm 10$  MeV is found.

**20798.** Okabe, H. Fading of quinoline dye by light: Application to the measurement of the integrated lamp output and solar energy, *Appl. Opt.* 20, No. 23, 4054-4058 (Dec. 1, 1981).

Key words: fading; measurement of lamp output; plastic plate; quinoline dye; solar energy.

The fading rates of plastic plates dyed with a quinoline derivative (quinophthalone) have been measured under exposure to light of 336-, 404.7-, and 435.8-nm wavelengths and to a high pressure Xe arc. The initial quantum yield of fading is  $2 \times 10^{-5}$  and is independent of incident wavelengths. The correlation between the fading by lamp exposure and that by solar exposure is obtained using a filtered 1000-W Xe arc, a simulated solar radiation source. The fading plates provide simple and inexpensive means to measure the integrated lamp output and solar energy.

**20799.** McCarter, R. J. Combustion inhibition of cellulose by powders: Preliminary data and hypotheses, *Fire Mater.* 5, No. 2, 66-72 (June 1981).

Key words: cellulose; combustion; flame; inhibition; inorganic; powder; pyrolysis; retardant; smolder; thermogram.

Small-scale qualitative tests were used to screen 185 inorganic powders for flame and smolder inhibiting effects upon cellulose. Nearly half of the compounds inhibited smoldering. These were limited to inorganic salts whose anions include boron, phosphorus, sulfur or halogen. Over half of the compounds inhibited flaming, and about one-third inhibited both flaming and smoldering. Differences were found between the actions of the powders and of similar retardants used in other forms and conditions. An appendix is



included reporting the effects of alkali metal halides on the pyrolysis of cellulose. Implications of the results to the functioning of inhibitors are discussed.

**20800.** Rosenblatt, J. R.; Spiegelman, C. H. Discussion of: "A Bayesian Analysis of the Linear Calibration Problem," by William G. Hunter and Warren F. Lamboy, *Technometrics* 23, No. 4, 329-333 (Nov. 1981).

Key words: calibration; curve-fitting; statistics; uncertainty limits.

This contribution is part of an invited discussion of the statistical problems associated with the calibration of measurement instruments and procedures. It proposes five applications-oriented criteria for classifying statistical issues that arise in fitting and using calibration curves. Examples of nonlinear models and calibration experiments with correlated errors, and recalibration issues, illustrate the many statistical problems still to be investigated.

**20801.** Maki, A. G.; Sams, R. L. High-resolution infrared spectrum and structure determination for carbon diselenide ( $\text{CSe}_2$ ), *J. Mol. Spectrosc.* 90, 215-221 (1981).

Key words: bond distances; carbon diselenide; infrared; molecular structure; spectroscopy; vibrational spectra.

Measurements are given for the  $2\nu_1 + \nu_3$  and  $2\nu_2 + \nu_3$  bands (at 2031  $\text{cm}^{-1}$  and 1922  $\text{cm}^{-1}$  respectively) of an isotopically enriched sample of  $\text{C}^{80}\text{Se}_2$ . Band centers and rotational constants are given for the two bands. The ground state rotational constant is found to be  $B_0 = 0.0367831 \pm 0.0000100 \text{ cm}^{-1}$  and the equilibrium C-Se bond length is determined to be  $1.6917 \pm 0.0015 \text{ \AA}$ , slightly smaller than in  $\text{OCSe}$ .

**20802.** Mink, A.; Silio, C. B., Jr. A queueing network model of a shared device among independent computing systems, *Proc. Fifteenth Annu. Conf. Information Sciences and Systems*, Baltimore, MD, Mar. 25-27, 1981, pp. 418-423 (The Johns Hopkins University, Baltimore, MD 21218, 1981).

Key words: computer architecture; performance evaluation; performance modeling; queueing models; queueing networks; shared device.

A queueing network model of a special class of computer architecture is presented. The configuration of this class is that of several independent computing systems sharing a single processing resource. A space efficient algorithm is presented to evaluate the analytic expressions for this specific model. Because this algorithm requires only linear growth in memory space, this model can be applied to a larger subset of problems than can existing more general models with associated evaluation algorithms requiring exponential growth in memory space and time.

**20803.** Martin, W. C. Series formulae for the He I-like spectra Na X through Ar XVII ( $Z=11-18$ ), *Phys. Scr.* 24, 725-731 (1981).

Key words: atomic spectra; atomic wavelengths; He-like ions; isoelectronic sequence; spectra series; vacuum ultraviolet; x rays.

The constants in Rydberg-Ritz formulae have been evaluated for  $1snl$  series by fitting the lowest few terms. Each formula allows prediction of the energies of all terms of a particular type in a particular spectrum. Formulae are given for the  $^3S_1$ ,  $^1S_0$ ,  $^3P_0$ ,  $^3P_1$ ,  $^3P_2$ ,  $^1P_1$ ,  $^3D_{1,2}$ ,  $^3D_3$ ,  $^1D_2$ , and  $^1F_0$  series in each spectrum. The formulae for the  $S$  and  $P$  series are based on values of the lower terms calculated by Ermolaev and Jones, and thus effectively extend these calculations to all series members. Values of the  $1s4d$  and  $1s5d$  terms needed for derivation of the  $D$  formulae were obtained by procedures based on comparisons and use of several different calculations of the  $1s3d$  levels. The results for the higher  $D$  terms should be more accurate than previous values calculated without inclusion of the relativistic effects. Similar procedures were used in the derivation of the  $1snf$  formulae. The  $1snl$  term values for  $l \geq 4$  should be equal to the appropriate (relativistic) hydrogenic values to a good accuracy for these ions. The wavelengths of all transitions of the type  $1snl-1sn'l'$  can thus be predicted for these spectra.

**20804.** Kronenberg, S.; McLaughlin, W.; Siebentritt, C. R. Broad-range dosimetry with leuco dye optical waveguides, *Nucl. Instrum. Methods* 190, 365-368 (1981).

Key words: anomalous dispersion; dimethyl sulfoxide; dosimetry; fibre optics; gamma-ray dosimetry; leuco cyanides; neutron dosimetry; optical waveguides; radiochromic dyes.

Optical waveguides consisting of plastic tubing filled with a solution of leuco radiochromic dye are designed for use as ionizing radiation dosimeters. Anomalous dispersion near the radiation-induced absorption band of the dye solutions results in refractive index changes, permitting dosimetry with a dynamic range of absorbed dose, or dose equivalent, of at least six orders of magnitude.

**20805.** Gross, D. The role of committee E-5 in international standardization of fire tests, *ASTM Stand. News* 9, No. 12, 28-30, 41 (Dec. 1981).

Key words: ASTM E-5; fire tests; standards.

ASTM committee E-5's role in international fire test standardization dates back to February 1967 when the United States became an official participating member of ISO Technical Committee 92 on Fire Tests. Over the past fifteen years, the world-wide growth of interest in international standardization has been paralleled by a similar growth of interest among U.S. materials producers, testing laboratories and regulatory officials. As the U.S. Technical Advisory Group (TAG) to ISO TC 92, subcommittee E 5.34 representing E-5, has played a key role in planning, policy and information transfer.

**20806.** Deprit, A. Celestial mechanics: Never say No to a computer, *J. Guidance Control* 4, No. 6, 577-581 (Nov.-Dec. 1981).

Key words: algebra of series; celestial mechanics; orbit calculations.

The author presents an autobiographical review of orbital calculations 1950-1981, emphasizing the refinements which have evolved from a combination of analysis and automated algorithms.

**20807.** Cahn, J. W.; Larché, F. Surface stress and the chemical equilibrium of small crystals—II. Solid particles embedded in a solid matrix, *Acta Metall.* 30, 51-56 (1982).

Key words: coherency; composites; small particles; solid solutions; strain; surfaces; thermodynamics.

The equilibria of small solid particles embedded in a solid matrix are considered. Three interface quantities are of significance; an interfacial free energy representing the work of creating the interface and two interfacial stresses. One represents the work of stretching the interfaces while the other represents the work of stretching one crystal holding the other fixed and thereby altering the structure of the interface. The isotropic case is developed in detail. Several new effects result from the partial accommodation in the matrix of the stress field arising from interfacial stress. An elastic accommodation factor modifies the capillary contribution to the pressure in the particle, the chemical potentials and the Gibbs-Thomson effect. Diffusion potentials but not chemical potentials are constant throughout the system. Coherent and incoherent nucleation is reexamined.

**20808.** Blair, W. P.; Stencel, R. E.; Shaviv, G.; Feibelman, W. A. HM sagittae: Symbiotic cousin of the RS CVn stars?, *Astron. Astrophys.* 99, 73-79 (1981).

Key words: mass exchange; RS Canum Venaticorum binaries; spectrophotometry; stars, individual; symbiotic stars.

Spectrophotometry of the symbiotic-like object HM Sagittae is presented and compared with earlier observations. We find a decreased continuum and higher stage of ionization and excitation than has been previously seen. Comparison with V 1016 Cygni at the same stage after its outburst shows a qualitative similarity in the two spectra. The observations are examined in the context of the interacting single star wind model of planetary nebulae formation of Kwok and Purton (1979) and similarities and problems pointed out. Derived distances, pre-outburst colors and magnitudes for HM Sge are found to be inconsistent with the precursor having been a red giant, but rather like a K-type subgiant. The implication is that the object may not be a protoplanetary nebula, but a symbiotic epilog to an aged RS CVn interacting binary.



20809. Martin, J. W. The analysis of life data for wood in the bending mode, *Wood Sci. Technol.* 14, 187-206 (1980).

Key words: durability; duration of load; life data; life distribution; reliability; service life; wood.

The applicability of a proposed procedure based on accepted, reliable, statistics was evaluated for characterizing the duration of load properties of wood in bending. By subjecting small, clear, wood specimens to several constant stress levels, it was experimentally demonstrated that the proposed procedure is capable of estimating, at an acceptable level of confidence  $\delta$  the maximum service life beyond which a specified proportion  $\gamma$  of the nominal population will survive. The extension of this procedure to structural sized members seems plausible, since an estimate of the short term ultimate strength for each specimen is not required. Another attribute of the procedure is that parametric estimates can be computed without failing all of the specimens; thus this should significantly reduce the duration of load test time.

20810. Quintiere, J. G.; Rinkinen, W. J.; Jones, W. W. The effect of room openings on fire plume entrainment, *Combust. Sci. Technol.* 26, 193-201 (1981).

Key words: entrainment; flame angle; openings; plume; room fire.

The mass rate of entrainment is examined for a fire plume in a room. Entrainment rates are inferred from measurements of air flow through a door or window and from room temperature data. The effect of the air flow is to tilt the flame plume, and to increase the entrainment rate over that of a vertical free standing plume. Dimensional analysis and theoretical results for a non-reacting wind blown plume model are used to correlate the flame angle and entrainment rate results.

20811. Birky, M. M.; Paabo, M.; Brown, J. E. Correlation of autopsy data and materials involved in the Tennessee jail fire, *Fire Safety J.*, 2, 17-22 (1979/80).

Key words: autopsy; biological; carboxyhemoglobin; fatalities; hydrogen cyanide; polymer; toxicity.

During 1977, a number of major fires, resulting in multiple fatalities, have caused an enhanced concern about toxic gases that are generated from synthetic materials involved in the fire. One of these fires, the Maury County, Tennessee, jail fire, was unique in that the cell padding was the only material involved in the fire. Various officials from the State of Tennessee provided material samples for polymer identification and biological samples from victims for toxicological evaluation. The results of these measurements are presented. A correlation of the toxicological findings with the material involved in the fire is presented.

20812. Birky, M. M.; Halpin, B. M.; Caplan, Y. H.; Fisher, R. S.; McAllister, J. M.; Dixon, A. M. Fire fatality study, *Fire Mater.* 3, No. 4, 211-217 (1979).

Key words: alcohol; carbon monoxide; carboxyhemoglobin; cardiovascular disease; fire fatalities; hydrogen cyanide.

Over a six-year period, 530 fire fatalities resulting from 398 fires were studied in the State of Maryland. The study had two major objectives: (1) to determine the specific cause of death by a detailed autopsy study of fire victims, and (2) to determine the specific cause of fatality-producing fire by an on-the-scene fire investigation. The fire fatality study was limited to residential fires and to fatalities that occurred within 6 h of the fire. The results of the toxicological analysis show that (1) 60% of the victims had a carboxyhemoglobin value greater than or equal to 50% carbon monoxide saturation, (2) an additional 20% had elevated carboxyhemoglobin with preexisting cardiovascular disease, (3) 11% of the victims had severe burns, (4) 9% were unexplained and (5) 40% of the victims had positive blood alcohol levels with 30% of these meeting the legal definition of intoxication (blood alcohol  $>0.1\%$ ). The fire investigations confirmed that the predominant fatal scenario is the cigarette ignition of upholstered furniture or bedding. This scenario accounted for 47% of the fires and 44% of the victims. Alcohol also appears to be a significant factor in this scenario.

20813. Ehrlich, M. Choice of conversion factors to the shallow and deep dose equivalents for use in a U.S. personnel dosimetry performance testing programme, *Radiat. Prot. Dosim.* 1, No. 4, 271-275 (1981).

Key words: conversion factors; dose equivalent; field measurement; Health Physics Society; neutrons; photons; standard; testing program.

In June 1981, the Health Physics Society Standards Committee adopted a standard that will be used in a future mandatory U.S. personnel dosimetry performance testing programme. In this standard, a set of factors is specified for converting from the quantities generally used to characterize the radiation fields in which radiation protection instruments are calibrated to the shallow and the deep dose equivalent specified for reporting the results of future performance tests. For photons, the choice of these conversion factors was the cause of considerable controversy. For this reason, it was decided to publish this relatively detailed discussion of the considerations which were the basis for the choice of all the factors used.

20814. Wasson, O. A.; Meier, M. M. Measurements of the  $^{235}\text{U}$  mass in a large volume multiplated fission ionization chamber, *Nucl. Instrum. Methods* 190, 571-582 (1981).

Key words: ionization chamber; mass; neutron beam design; neutron fission; uranium-235.

The mass of  $^{235}\text{U}$  contained in a large-volume multideposit fission ionization chamber used for neutron cross section experiments was measured relative to the National Bureau of Standards reference deposit 25S-2-1. The mass ratio utilized the thermal neutron induced fission reaction in a uniform 25 cm diameter neutron beam from the thermal column of the NBS reactor. The mass was independent of the geometrical area and areal density variation of the deposits, absolute neutron flux, thermal neutron energy distribution, and neutron cross sections. The  $^{235}\text{U}$  mass in the chamber is  $170.9 \times 10^{-3}$  g with a one standard deviation uncertainty of 1.2%.

20815. Kaufman, V.; Sugar, J. Ag I isoelectronic sequence: Wavelengths and energy levels for I VII through La XI, *Phys. Scr.* 24, No. 4, 738-741 (1981).

Key words: Ba X; Cs IX; I VII; La XI; wavelengths; Xe VIII.

New and more complete observations of the Ag I isoelectronic sequence from I VII through La XI are used to derive energy levels and ionization energies for these ions. Predictions are obtained from these data for the positions of the  $4f^2F$  levels based on estimated values for the  $5g$  effective quantum number  $n^*$ .

20816. Basri, G. S.; Linsky, J. L.; Eriksson, K. Outer atmospheres of cool stars. VIII. *IUE* observations and chromospheric models for the supergiant stars  $\beta$  Draconis,  $\epsilon$  Geminorum, and  $\alpha$  Orionis, *Astrophys. J.* 251, No. 1, 162-180 (Dec. 15, 1981).

Key words: late-type stars; stars, individual; stellar atmospheres; stellar chromospheres; ultraviolet spectrum.

We extend our program of semiempirical modeling of stellar chromospheres to a previously unstudied portion of the H-R diagram—the late-type supergiants. These models were computed to match high-resolution absolute flux profiles of the Ca II K and Mg II  $h$  and  $k$  lines. In our *IUE* ultraviolet spectra of  $\epsilon$  Gem and  $\alpha$  Ori we find no evidence for emission lines formed at temperatures hotter than  $\sim 10^4$  K, and on this basis we compute chromospheric models which extend to  $m=10^{-6}$  g  $\text{cm}^{-2}$  at temperatures rising to 6500 K and 7000 K, respectively. Upper limits on the surface flux of the C IV  $\lambda 1549$  emission feature in  $\epsilon$  Gem are 0.1 that of the quiet Sun, and in  $\alpha$  Ori the upper limits are 0.002 that of the quiet Sun, providing upper limits on the amount of  $10^5$  K plasma in these stars. By contrast,  $\beta$  Dra shows strong emission lines of C II-IV, Si IV, He II, and N V. We tentatively extend the  $\beta$  Dra chromospheric model up to 16,000 K at  $P_0=2n_kT=0.012$  dynes  $\text{cm}^{-2}$ . However, density-sensitive line ratios suggest  $P_0=0.3$  dynes  $\text{cm}^{-2}$  at 60,000 K, and we discuss possible explanations for the discrepancy.

Chromospheric models for supergiants are more uncertain than for giants and dwarfs because low stellar gravity results in low



chromospheric densities and thus highly coherent scattering in the wings of the Ca II and Mg II resonance lines. We take this coherency into account in our partial redistribution (PRD) code, but it results in the line wings being insensitive to local atmospheric parameters at the base of the chromosphere. The highly asymmetric line profiles for  $\beta$  Dra are modeled with a comoving PRD code which assumes a sinusoidal variation of vertical velocity amplitude with positive (outward) velocity maximum near the temperature minimum and negative (inward) velocity maximum near  $m=10^{-2}$  g cm $^{-2}$  (near  $\tau_K \approx 1$ ). This velocity structure is ad hoc, but it is qualitatively consistent with a circulation pattern like solar supergranulation in which bright regions (network) are downflows and dark regions (cells) are upflows. We discuss alternative explanations. Finally, we point out that our analyses of the Ca II and Mg II lines, assuming hydrostatic equilibrium with only thermal and turbulent components to the pressure, imply nearly plane-parallel chromospheres, even for  $\alpha$  Ori. Since other data suggest considerable geometrical extent for the chromospheres of  $\alpha$  Ori and other  $M$  supergiants, future models should include geometrical extension when estimates of nonthermal components of the pressure become available.

**20817.** Maki, A. G.; Lovas, F. J.; Suenram, R. D. **Infrared spectrum of boron chloride (BCl),** *J. Mol. Spectrosc.* **91**, 424-429 (1982).

**Key words:** bond distance; boron chloride; diode lasers; Dunham coefficients; infrared; spectra; unstable molecules.

The spectrum of the  $\Delta v=1$  band of BCl was measured between 828 and 870 cm $^{-1}$  with a tunable diode laser. The absorptions of the  $v=1-0$ ,  $2-1$ ,  $3-2$ , and  $4-3$  transitions of BCl were observed in both a microwave discharge and a dc discharge through BCl $_3$ . Spectra of  $^{11}\text{B}^{35}\text{Cl}$ ,  $^{11}\text{B}^{37}\text{Cl}$ ,  $^{10}\text{B}^{35}\text{Cl}$ , and  $^{10}\text{B}^{37}\text{Cl}$  were observed in natural abundance. A set of eight was determined by fitting the data for all observed isotopic species with the appropriate reduced mass factors. A B-Cl bond distance,  $r_e=0.1715283(31)$  nm, was determined which agrees with value derived from the electronic spectrum of BCl. The band center for the  $v=1-0$  transition of  $^{11}\text{B}^{35}\text{Cl}$  is  $\nu_0=829.4087(8)$  cm $^{-1}$ .

**20818.** Ledbetter, H. M.; LaBrecque, J. F.; Dahnke, J. L. **Propagation errors in elastic-constant inversion,** *Phys. Status Solidi A* **67**, 643-647 (1981).

**Key words:** elastic constants; error propagation; matrix inversion; physical property.

Physical-property tensors obtained through matrix inversion may inherit large errors, which may be asymmetric. Analysis of the cubic-symmetry elastic-constant case where stiffnesses ( $C_{ij}$ 's) are converted to compliances ( $S_{ij}$ 's), and vice versa, shows dramatic error-propagation, depending on the  $C_{12}/C_{11}$  ratio.

**20819.** Garvin, D. **Thermodynamic properties of the elements,** *Bull. Alloy Phase Diagrams* **2**, No. 2, 261-262 (1981).

**Key words:** elements; enthalpy; entropy; evaluated data; heat capacity; thermodynamics.

A table is provided of entropies and heat capacities at 298.15 K enthalpy differences between 298.15 K and 0 K and enthalpies of sublimation at 0 K for the chemical elements. The values are drawn from major critical evaluations of chemical thermodynamic properties.

**20820.** Watson, R. E.; Swartzendruber, L. J.; Bennett, L. H. **Bonding effects in dilute transition-metal alloys,** *Phys. Rev. B* **24**, No. 11, 6211-6220 (Dec. 1, 1981).

**Key words:** alloying; alloy phase diagrams; charge transfer; hybridization; isomer shift; Mössbauer effect.

The Mössbauer isomer-shift data of transition-metal nuclei as impurities in metals were considered in previous papers where it was shown that, once volume effects were suitably accounted for, the data fell on a "universal" curve. In this paper, the deviations from universality are examined in more detail in an attempt to better understand the alloying behavior. It is found that atom  $A$  as an impurity in metal  $B$  does not sustain a shift of the same magnitude as atom  $B$  does when it is an impurity in metal  $A$ . The results are discussed in terms of  $d$ -band hybridization and of the asymmetry in

the solubility behavior in transition-metal-alloy phase diagrams.

**20821.** Bernasek, S. L.; Leone, S. R. **Direct detection of vibrational excitation in the CO $_2$  product of the oxidation of CO on a platinum surface,** *Chem. Phys. Lett.* **84**, No. 2, 401-404 (Dec. 1, 1981).

**Key words:** catalysis; chemiluminescence; CO; oxidation; platinum surface.

Infrared chemiluminescence techniques are applied to the study of vibrationally excited surface reaction products. The method is demonstrated by the detection of infrared emission from highly excited CO $_2$  product molecules in the reaction of CO with O on a platinum surface.

**20822.** Pardowitz, I.; Hess, S. **Elasticity coefficients of nematic liquid crystals,** *J. Chem. Phys.* **76**, No. 3, 1485-1489 (Feb. 1, 1982).

**Key words:** elasticity coefficients; nematic liquid crystals.

A Ginsburg-Landau type ansatz for the Gibbs free energy is introduced which involves the alignment tensors of ranks 2 and 4 and their spatial derivatives. It is applicable to both the isotropic and nematic phases. The Frank elasticity coefficients of the nematic phase are expressed in terms of the equilibrium order parameters and phenomenological coefficients which are related to bare correlation length coefficients. The full anisotropy of the elasticity coefficients is obtained and their experimentally observed temperature dependence can be reproduced for all of the ten substances which have been analyzed.

**20823.** Blue, J. L.; Wilson, C. L. **Calculating eigenvalues and eigenfunctions using an interior constraint,** *J. Comput. Phys.* **44**, No. 1, 70-83 (Nov. 1981).

**Key words:** adaptive meshes; eigenvalues; elliptic equations; finite elements; multi-level iterations; triangulations.

A new method for calculating eigenvalues and eigenfunctions of elliptic operators is presented. An interior constraint is used to allow reliable convergence to any desired eigenfunction. The method has been implemented in a portable Fortran computer program which features adaptively generated triangulations in two dimensions, and which uses multi-level iteration. The program has been used to calculate efficiently eigenvalues and eigenfunctions on singly- and multiply-connected regions, with internal and boundary singularities.

**20824.** Myers, D. R.; Comas, J.; Wilson, R. G. **Effect of silicon dioxide surface-layer thickness on boron profiles for directly aligned implants into (100) silicon,** *J. Appl. Phys.* **52**, No. 5, 3357-3359 (May 1981).

**Key words:** boron; dopant profile control; ion channeling; ion implantation; silicon; silicon dioxide.

We report boron profiles as determined by secondary ion mass spectrometry that result from implantation into (100) silicon at  $(0.0 \pm 0.1)$  degrees through various thicknesses of thermally grown silicon dioxide. The implants were performed at room temperature at 150 keV to a fluence of  $4.0 \times 10^{13}$ /cm $^2$ . The oxide surface layers examined were 7.6, 33.6, 101.5, or 140.0 nm thick as determined by ellipsometry. The boron profile for implantation through the 7.6-nm oxide surface layer was only slightly degraded from that seen for accurately aligned implantations into bare (100)-oriented silicon, while implantation through the three thicker oxides results in profiles similar to those obtained from random equivalent implantations into crystalline silicon. The systematics of the dechanneling of the implanted boron as a function of the thickness of the amorphous surface layer are analyzed and discussed.

**20825.** Yates, J. T., Jr. **The structural factor in chemisorption and heterogeneous catalysis—A review,** *Vacuum* **31**, Nos. 10-12, 715-722 (1981).

**Key words:** CH $_4$ ; decomposition; heterogeneous catalysis; hydrogen; methanation; NH $_3$ ; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111).

We have now entered an era where the influence of surface structure on the kinetics of catalytic processes may be directly investigated using single crystal substrates. Catalytic processes whose



rates are sensitive to substrate structure, and those which seem to be structure insensitive have now been studied, and several examples are described here. It is shown that there may be large differences in both reactivity and reaction mechanism for ordered and disordered chemisorbed species. It is also shown that structure insensitive heterogeneous reactions may occur in cases where the coverage of a reactant is below one monolayer—suggesting that the leveling of crystallographic differences between different planes by an adsorbate is not a useful general model for explaining rate insensitivity to substrate structure. Conversely, structural sensitivity may occur in cases where a high coverage of adsorbate is present, again in violation of the general model.

Because of the many complex factors known to be involved in governing the rate of heterogeneous catalytic reaction, it is concluded that there may be a number of system-dependent explanations for the common occurrence of structural insensitivity, and that a general model for this surprising behavior may not exist.

**20826.** Rubin, R. J.; Weiss, G. H. Random walks on lattices. The problem of visits to a set of points revisited, *J. Math. Phys.* **23**, No. 2, 250-253 (Feb. 1982).

Key words: absorbing points; lattice random walk; mean occupation time; polymer adsorption; probability of first return; restricted random walk.

A general method is outlined for calculating the statistical properties of the number of visits to a set of points in a random walk. In illustrative examples, known results and new results are easily derived.

**20827.** Candela, G. A.; Galloway, K. F.; Liu, Y. M.; Fine, J. Measurement of the interlayer between aluminum and silicon dioxide using ellipsometric, capacitance-voltage and Auger electron spectroscopy techniques, *Thin Solid Films* **82**, 183-193 (1981).

Key words: aluminum-oxide interlayer; Auger; capacitance-voltage; electron devices; ellipsometric; integrated circuits.

Ellipsometric and capacitance-voltage measurements were combined to detect both the Al-SiO<sub>2</sub> interlayer and the Si-SiO<sub>2</sub> interlayer for the Si/SiO<sub>2</sub>/Al system. The Al-SiO<sub>2</sub> interlayer was characterized by Auger electron spectroscopy (AES), combined with argon ion sputter profiling, of the Al/SiO<sub>2</sub>/Si structure and also of the remaining SiO<sub>2</sub>/Si structure after the aluminum had been chemically removed. An effective interlayer thickness is defined as the product of the interlayer thickness and the fractional change in the dielectric SiO<sub>2</sub> constant. The results of these experiments indicate that the Al-SiO<sub>2</sub> effective interlayer thickness has a range of 0.1–0.5 nm. The AES data can be readily interpreted if it is assumed that collision cascade mixing and recoil implantation occur as a consequence of sputter depth profiling through the aluminum.

**20828.** Baghdadi, A.; Forman, R. A. Tertiary interferograms in Fourier transform spectroscopy, *Appl. Spectrosc.* **35**, No. 5, 473-475 (1981).

Key words: FT-IR; infrared; interferograms, tertiary; methods, analytic; silicon; techniques, spectroscopic.

Multiple passes, both within a semiconductor specimen and between the specimen surface and the interferometer, give rise to a series of extraneous "tertiary" interferograms in a Fourier transform spectrophotometer. These tertiary interferograms can lead to a possible error on the order of 1% in the measurement of the impurity content of a silicon wafer. However, this effect can be eliminated by a straightforward manipulation of the interferogram prior to transformation.

**20829.** Bullis, W. M.; Ehrstein, J. R. Reference materials and the semiconductor industry, *Solid State Technol.*, pp. 56-63 (Nov. 1981).

Key words: measurements; metrology; reference materials; semiconductors; silicon; standard reference materials.

The development of increasingly sophisticated semiconductor technologies such as VLSI will put increasingly stringent demands on materials and fabrication processes as well as on the measurement techniques used to characterize them. The advent of many new measurement techniques and instruments, often noncontacting and

automatic, has offered convenience to the user, but many times it is at the price of measurements which are inconsistent with those obtained by more traditional techniques. The Standard Reference Material (SRM) program at the National Bureau of Standards, which provides calibrated artifacts to various user communities, is one approach for improving measurement accuracy and compatibility. This article describes the SRM program at NBS and the requirements for effective utilization of SRMs. Application of the SRM program to the semiconductor industry is discussed both with respect to present and planned SRMs and with regard to meeting the more extensive and longer range needs of the industry.

**20830.** Lowney, J. R.; Kahn, A. H.; Blue, J. L.; Wilson, C. L. Disappearance of impurity levels in silicon and germanium due to screening, *J. Appl. Phys.* **52**, No. 6, 4075-4080 (June 1981).

Key words: anisotropic Yukawa potential; finite element; germanium; heavily doped semiconductors; impurity levels; silicon.

We have studied the disappearance of impurity levels in silicon and germanium due to free-carrier screening of the Coulomb field of the impurity ions. The ground-state eigenfunctions and eigenvalues have been calculated for electrons described by an ellipsoidal effective-mass Hamiltonian. A two-dimensional finite-element analysis was used to obtain the solutions. Only moderate carrier densities ( $10^{19}$  cm<sup>-3</sup> for silicon and  $10^{18}$  cm<sup>-3</sup> for germanium) are needed to cause the impurity levels to disappear into the conduction band, the result at high doping densities being simply a degenerate semiconductor.

**20831.** Roder, H. M.; Nieto de Castro, C. A. Thermal conductivity of liquid propane, *J. Chem. Eng. Data* **27**, No. 1, 12-15 (Jan. 1982).

Key words: liquid; propane; thermal conductivity; transient hot wire.

The paper presents new experimental measurements of the thermal conductivity of liquid propane for seven isotherms from 110 to 300 K with pressures to 70 MPa, i.e., a total density range of 11–16.5 mol/L (484–726 kg/m<sup>3</sup>). It is estimated that the overall uncertainty in the thermal conductivity is 1.5%. The data can be represented with an equation which is based on an existing correlation. The data are compared to the experimental measurements of others in the liquid state. Values for the saturated liquid are established by using the equation.

**20832.** Hanson, D. M.; Stockbauer, R. L.; Madey, T. E. Photon-stimulated desorption and other spectroscopic studies of the interaction of oxygen with a titanium (001) surface, *Phys. Rev. B* **24**, No. 10, 5513-5521 (Nov. 15, 1981).

Key words: electron stimulated desorption; ESD; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS.

Synchrotron radiation at the Synchrotron Ultraviolet Radiation Facility at the National Bureau of Standards has been employed to study the adsorption of oxygen on a Ti(001) surface using photon-stimulated desorption (PSD), electron-stimulated desorption (ESD), and ultraviolet photoemission spectroscopy (UPS). The dominant ESD and PSD products observed for oxygen exposures greater than one langmuir are O<sup>+</sup> ions having a most probable kinetic energy of about 3 eV. The photon energy dependence of the PSD ion yield is similar to the major features of the constant final-state secondary-electron yield although there are some differences in detail. This similarity is consistent with the O<sup>+</sup> desorption being initiated by the production of a Ti 3p core hole as suggested by the Knotek-Feibelman Auger decay mechanism. The dependence of the O<sup>+</sup> ion yield on oxygen exposure and surface temperature is compared with UPS and work-function measurements. These data indicate that surface oxidation occurs at temperatures as low as 90 K and that at least a fraction of the surface oxide is electronically similar to the maximal valency compound TiO<sub>2</sub>.

**20833.** Marchetti, M. C.; Dufty, J. W. Bound-state and finite-collision-time effects in the binary-collision approximation, *Phys. Rev. A* **24**, No. 4, 2116-2134 (Oct. 1981).

Key words: atom pairs; binary-collision approximation; bound



state effects; finite collision time effects.

The kinetic theory for time-correlation functions at low density is studied for potentials with bound states and finite collision times. The contribution to the binary-collision operator from bound pairs of atoms with arbitrarily large interaction times is shown to exist and to vanish for times large compared to the characteristic scattering time, justifying the Boltzmann limit for potentials with attractive parts. The effects of such bound states and finite collision times on the short-time behavior of correlation functions are illustrated by a detailed calculation of the velocity-autocorrelation function for a square-well potential. Good agreement with the corresponding results from molecular dynamics is obtained.

**20834.** Collé, R. **Radon measurements: National needs and the role of NBS**, (Proc. Conf. Am. Nucl. Soc. 1981 Winter Meet., San Francisco, CA, Nov. 29-Dec. 3, 1981), *Trans. Am. Nucl. Soc.* **39**, 84-86 (American Nuclear Society, 555 N. Kensington Avenue, LaGrange Park, IL 60525, 1981).

Key words: calibration; measurement; quality assurance; radon; standards.

This summary briefly highlights the existing state of services required to support the measurement of radon and related quantities, and describes the need for readily available measurement standards, calibration services, and measurement assurance mechanisms.

**20835.** Buehler, M. G.; Linholm, L. W. **Toward a standard test chip methodology for reliable, custom integrated circuits**, (Proc. 1981 Custom Integrated Circuits Conf., Rochester, NY, May 11-13, 1981), *IEEE Cat. No. 81CH1636-0*, pp. 142-146 (Institute of Electrical and Electronics Engineers, Rochester, NY, 1981).

Key words: custom; integrated circuits; multifunction; parametric tester; reliability; standard; test chip; test structure.

The microelectronic test chip is an important tool in the design and production of reliable, custom integrated circuits. The role of test chips is expanding from a wafer fabrication process control monitor to a vehicle which provides circuit design parameters needed for layout rule definition, circuit simulation, and logic simulation. The test chip is being used more extensively to verify that circuit design parameters are achieved during fabrication. Used in this way, the test chip serves as a transactional vehicle for use in the buying and selling of integrated circuit wafer fabrication services. Such transactions require standards which do not now exist. This paper describes a proposed test structure taxonomy, explores the need for test chips, and discusses the characteristics of a standard test chip methodology.

**20836.** Tsai, D. H.; Trevino, S. F. **Thermal relaxation in a dense liquid under shock compression**, *Phys. Rev. A* **24**, No. 5, 2743-2757 (Nov. 1981).

Key words: continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation.

We have studied the molecular dynamics of the propagation of a planar shock wave in a dense, three-dimensional column of a simple Lennard-Jones liquid. The column is 18 unit cells (fcc) in cross-section, 144 unit cells in length and contains about 10,000 atoms. The column is initially in equilibrium at a density of  $0.85\sigma^{-3}$  and temperature of  $1.16\epsilon/k$ . Shock compression is effected by causing the column to move in the longitudinal direction with a velocity of  $-U_p$  and to collide with its mirror image across a mirror located at the origin. From the motion of the atoms in response to this kind of excitation, we calculate the shock velocity and the shock front structure in the liquid, as well as the profiles of mass density, stress distribution and energy density behind the shock front. Our shock front structure agrees well with that obtained from the Navier-Stokes equations, but we also find important differences between our shock profiles and those postulated or computed from the continuum theory. In particular, we find that in  $4.1 \times 10^{-11}$  s, the longest time of our calculations, the stress components did not relax to a hydrostatic condition, but the corresponding kinetic temperature profile showed a relaxation process similar to what we found earlier in a crystalline solid. We examine the atomistic mechanisms of the various relaxation

processes, and discuss their implications on the shock compression of dense systems of solids and liquids as opposed to rare systems of gases.

**20837.** Yap, W. T.; Durst, R. A. **Electron transfer to and from molecules with interacting multiple redox centers**, *J. Electroanal. Chem.* **130**, 3-8 (1981).

Key words: electron transfer; electron transfer model; interacting multiple redox centers; interaction energies; nearest neighbor interactions.

A theoretical analysis is given for electron transfer in molecules with interacting multiple redox centers such as dimers, oligomers and polymers, and for voltammetric techniques such as dc polarography and rotating disk voltammetry. The analysis takes account of the interactions between nearest-neighboring centers only. The determination of the interaction energies from the experimental current-potential curves is illustrated.

**20838.** Linholm, L. W.; Mattis, R. L.; Frisch, R. C.; Reeve, C. P. **Characterizing and analyzing critical integrated circuit process parameters**, *Semicond. Silicon* **81-5**, 906-920 (Electrochemical Society, Inc., 10 South Main Street, Pennington, NJ 08534, May 1981).

Key words: integrated circuits; microelectronics; process control; process validation wafer; test pattern; test structure; wafer map.

Microelectronic test structures are frequently used to measure the degree of process control in developmental integrated circuit processes. Test results from these structures must be obtained and interpreted in a timely fashion in order to be used for correcting or improving the process. This paper describes techniques for determining and displaying critical process parameters in forms convenient for characterizing the intrawafer variation of these parameters.

**20839.** Carpenter, R. J.; Malcolm, J. E.; Strawbridge, M. L. **Operational experience with the NBS local area network**, (Proc. IFIP Working Group 6.4 Int. Workshop Local Networks, Zürich, Switzerland, Aug. 27-29, 1980), Paper in *Local Networks for Computer Communications*, A. West and P. Janson, eds., pp. 43-60 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1981).

Key words: broadcast; coaxial; communication; contention; data; digital; Ethernet; local; microprocessor; network; serial.

The local area network designed and built at the National Bureau of Standards (NBSNET) has been in routine use since October 1979, and now serves about 70 user devices in eight different buildings. It employs a carrier sense multiple access, collision detection (CSMA-CD), protocol with a one megabit per second data rate and Manchester encoding on the coaxial distribution cable. The system contains a number of repeater amplifiers because of the site topology and a desire to keep signal levels within a small dynamic range. The current user devices are primarily graphic and alphanumeric terminals, with a smaller number of mini- and microcomputers. Both terminal access and file transfer protocols have been implemented. Most nodes keep traffic and error statistics during each connection and report the information to a central logging node when the connection terminates.

Our experience to date shows that users are often strongly geographically clustered, that the last 15 meters of the connection to the user are the most difficult and expensive, that a network measurement system is required to identify marginal conditions in the network, and that networks of this type are reliable. Information about network failures and installation costs is presented.

**20840.** Broadhurst, M. G.; Davis, G. T.; DeReggi, A. S.; Roth, S. C.; Collins, R. E. **Pyroelectricity and charge transport in a copolymer of vinylidene fluoride and tetrafluoroethylene**, *Polymer* **23**, 21-28 (Jan. 1982).

Key words: charge transport; copolymer; electrical properties; piezoelectricity; poling; pyroelectricity; tetrafluoroethylene; vinylidene fluoride.

A copolymer of vinylidene fluoride and tetrafluoroethylene shows pyroelectric and piezoelectric effects after poling. Thermal pulsing



measurements indicate that the polarization in this material is highly non-uniform. The piezo/pyroelectric response of this non-uniformly poled copolymer consists of two parts: a rapid response that is the result of changes in internal polarization, and a delayed response due to reversible motion of real charge through the bulk of the material. This model explains previously reported observations of the independence of pyroelectric response over a wide range of poling conditions.

**20841.** Mathey, R. G.; Rossiter, W. J., Jr. A preliminary evaluation of the tensile and elongation properties of single-ply sheet roofing membrane materials, *Proc. 2d Int. Conf. Durability of Building Materials and Components*, Gaithersburg, MD, Sept. 14-16, 1981, pp. 442-451 (National Bureau of Standards, Center for Building Technology, Washington, DC 20234, 1981).

Key words: elongation; exposure conditions; membrane properties; roofing membranes; single-ply roofing; tensile strength; test methods.

A summary is presented of the results of a preliminary evaluation of two performance properties, tensile strength, and ultimate elongation, of nineteen single-ply sheet roofing membrane materials. Also reported are the changes in mass and length of the membrane materials caused by exposure to heat. The nineteen materials represented the general categories of single-ply sheet membranes (elastomeric, plastomeric, and modified bitumens) and were typical of those used in the United States. Membrane materials included neoprene, ethylene propylene diene terpolymer, chlorosulphonated polyethylene, polyvinyl chloride, chlorinated polyethylene, and modified bitumens. The membrane materials were tested in tension before and after exposure to heat, and heat followed by ultraviolet radiation from a xenon arc. Control (unexposed) specimens were tested at 70 and 0°F and the exposed specimens were tested at 0°F. Three ASTM tensile test procedures were selected to determine the tensile and elongation properties of the membrane materials. All nineteen materials were tested according to a procedure for rubber. The plastics and modified bitumens were also tested according to procedures applicable to reinforced fabrics and bituminous roofing membranes, respectively.

**20842.** Forman, R. A.; Larrabee, R. D.; Myers, D. R.; Phillips, W. E.; Thurber, W. R. Processing effects on the electrical and optical properties of sulfur-related defect centers in silicon and similarities to the oxygen donor, (Proc. 1980 Annu. Meet. Materials Research Society, Boston, MA, Nov. 16-20, 1980), Paper in *Defects in Semiconductors*, Narayan and Tan, eds., pp. 79-84 (North-Holland Publ. Co., Inc., New York, NY, 1981).

Key words: chemical interactions; deep-level measurements; defects; optical properties; silicon; sulfur.

The properties of sulfur-related defects in silicon are shown to differ dramatically from those that would have been expected on the basis of effective mass theory for a simple substitutional double donor. The ratio of the densities of the sulfur states as measured by capacitance-voltage techniques has been observed to vary in specimens fabricated from the same starting resistivity. Optical absorption studies have shown that the deepest sulfur level has a manifold of ground states which anneal at unequal rates at 550°C. Deep-level measurements show that the thermal emission rate at a given temperature and the variety of effects produced depends on annealing history and total sulfur density. The variability of properties of samples of sulfur-doped silicon is similar to those found for the oxygen donors in silicon, thus suggesting a chemical trend for the column VI impurities in silicon.

**20843.** Rossiter, W. J., Jr.; Mathey, R. G.; Busching, H. W.; Cullen, W. C. Cooling time of hot bitumen during built-up roofing construction, *Proc. 2d Int. Symp. Roofs and Roofing*, Brighton, England, Sept. 21-24, 1981, pp. 489-497 (Agrément Board, London, England, 1981).

Key words: asphalt viscosity; bitumen cooling time; roofing bitumens.

The most widely accepted waterproofing system for low-sloped roofs in the United States is bituminous built-up roofing. In the construction of bituminous built-up roofing systems, hot bitumen is generally applied to roofing components such as deck, insulation, and

felts in order to adhere them to each other and to form a waterproof membrane. Bitumens commonly used as waterproofing materials and adhesives in built-up membranes are asphalt and coal tar pitch.

**20844.** McLaughlin, W. L.; Humphreys, J. C.; Levine, H.; Miller, A.; Radak, B. B.; Rativanich, N. The gamma-ray response of radiochromic dye films at different absorbed dose rates, (Proc. 3d Int. Meet. Radiation Processing, Tokyo, Japan, Oct. 24, 1981), *Radiat. Phys. Chem.* 18, No. 5-6, 987-999 (1981).

Key words: bleaching of dyes; dose rate; dosimetry; dyes; film dosimetry; gamma rays; humidity effects; leucocyanines; pulse radiolysis; radiation processing; radiochromic dyes.

In leucotriphenylmethane radiochromic dye systems, using polymeric host materials, low-intensity rate dependence of gamma-ray response at doses  $> 10$  kGy and at dose rates  $< 1$  Gy·s<sup>-1</sup> is observed in some dye-plastic combinations. This effect is prevalent under dry or anoxic conditions, and accompanies a shift in the optical absorption band. Whether or not the net dye yield becomes sublinear with dose and diminishes with decreasing dose rate is determined by environmental effects (e.g., relative humidity) and especially by the nature of the host material. Experiments at absorbed dose rates between 0.01 and 3 Gy·s<sup>-1</sup> show that the apparent low-intensity dose rate dependence is due mainly to a moisture-controlled decrease in efficiency of radiation-induced dye formation at relatively low radiation intensities. For several hydrophilic dosimeters, the thinner the film, the greater the dose rate effect. With the exception of polyvinyl pyrrolidone and the very thin films, there is only slight rate dependence at intermediate relative humidity.

**20845.** Reader, J.; Luther, G. The copper isoelectronic sequence: Ba<sup>27+</sup>-W<sup>45+</sup>, *Phys. Scr.* 24, 732-737 (1981).

Key words: barium; dysprosium; energy levels; erbium; gadolinium; neodymium; samarium; spectrum; tantalum; tungsten; ytterbium.

The spectra of the copper-like ions Ba<sup>27+</sup>, La<sup>28+</sup>, Nd<sup>31+</sup>, Sm<sup>33+</sup>, Gd<sup>35+</sup>, Dy<sup>37+</sup>, Er<sup>39+</sup>, Yb<sup>41+</sup>, Ta<sup>44+</sup>, and W<sup>45+</sup> have been observed with a laser-produced plasma and a 2.2 m grazing incidence spectrograph. Wavelengths, energy levels, and ionization energies are presented for each of these ions.

**20846.** Greene, R. L. Comments on the requirements for a general Stark broadening theory, *J. Quant. Spectrosc. Radiat. Transfer* 27, No. 2, 185-190 (1982).

Key words: line broadening; model microfield; plasma; Stark; strong collisions.

An analysis is made of requirements for a general theory of Stark broadening applicable to both strong and weak collisions. It is pointed out in particular that inclusion of the static and weak interaction limits is not sufficient to obtain a generally valid theory. At least one other condition is necessary—a dynamic correction for strong, primarily static, collisions. The kangaroo process model microfield method is examined from this point of view, and it is shown that the model conditional probability leads to an incorrect functional form for the lowest order dynamic correction.

**20847.** Bowen, R. L. Historical development of dental composite resins, *Dent. Diamond (Japanese)* 6, No. 13, 8-15 (1981).

Key words: acid etch; BIS-GMA; bonding; composites; dental resins; fillers.

As requested, this essay (which will be translated by Professor Ikuro Ohmorie, Tsurumi University, before publication in the Japanese language in the dental journal, *Dental Diamond*) describes the origin and historical development of the dimethacrylate monomer, known in the dental literature as "BIS-GMA". The need for composite resins was based in the shortcomings of the two esthetic direct restorative materials available in 1953: silicate cements and direct filling resins based on methyl methacrylate. The first attempts to make an improved direct filling material using an epoxy resin together with fused quartz or porcelain reinforcing filler particles were unsuccessful. A hybrid monomer was synthesized from bisphenol A and glycidyl methacrylate; it was from this reaction that the acronym "BIS-GMA" was derived. Since the first synthesis of BIS-GMA in



October 1956 (at the National Bureau of Standards) this monomer has come into widespread use. Although its primary use is as a binder for reinforcing fillers to form composite restorative materials, it is also used without additional fillers as a fissure sealant resin to prevent decay in newly erupted teeth. New resins and techniques are being developed, and further improvements can be expected.

**20848.** McNall, P. E., Jr. Building ventilation measurements, predictions, and standards, (Proc. Symp. Indoor Air Pollution, Committee on Public Health, New York Academy of Medicine, New York, NY, May 28-29, 1981), *Bull. N.Y. Acad. Med.* 57, No. 10, 1027-1042 (Dec. 1981).

Key words: air pollution modeling; air quality; contaminant control; standards; tobacco smoke; ventilation.

This paper discusses the energy importance of reduced ventilation. The new ASHRAE Standard 62-1981, Ventilation for Acceptable Indoor Air Quality, and extensive field measurements of ventilation are discussed. A predictive model for indoor air contaminant concentrations in residences and its verification are presented and the effects of several variables are discussed. Additional research on the indoor emanation rates of contaminants which are or may be health hazards would enable the prediction of indoor contaminant levels with various control options. Such predictions could be used to verify or refine indoor air quality standards.

**20849.** Berning, D. Use of vacuum tubes in test instrumentation for measuring characteristics of fast high-voltage semiconductor devices, *IEEE Trans. Instrum. Meas.* IM-30, No. 3, 226-227 (Sept. 1981).

Key words: clamping; diode recovery; high power measurements; high voltage; overshoot; power semiconductors; reverse-bias second breakdown; testing; voltage.

Circuits are described that permit measurement of fast events occurring in power semiconductors. These circuits were developed for the dynamic characterization of transistors used in inductive-load switching applications. Fast voltage clamping using vacuum diodes is discussed, and reference is made to a unique circuit that was built for performing nondestructive, reverse-bias, second-breakdown tests on transistors.

**20850.** Paffenbarger, G. C.; Rupp, N. W.; Waterstrat, R. M. Metals in solution in mercury expressed from copper-rich dental amalgams, *J. Dent. Res.* 61, No. 1, 30-32 (Jan. 1982).

Key words: dental amalgam; mercury; solubility of alloys in mercury.

Metals dissolved in excess mercury expressed from copper-rich amalgams ranged from 0.06 to 0.63 wt %. Such small percentages are not likely to affect pertinent properties. The solubility data may assist in explaining the kinetics of hardening of amalgams.

**20851.** Kahn, A. H.; Lowney, J. R. Effect of impurity pairs on the disappearance of impurity levels in silicon, *J. Appl. Phys.* 53, No. 1, 454-456 (Jan. 1982).

Key words: finite element; heavily doped semiconductors; impurity levels; silicon.

We report calculations of the binding energy of an electron to a pair of charged donor ions in the presence of screening by free carriers. The effective-mass approximation was assumed. We used a two-dimensional finite-element analysis to obtain numerical solutions, as we did in a previous study of the screening of single donor ions. The ground state was found to disappear into the conduction band at a doping level of  $1.27 \times 10^{19} \text{ cm}^{-3}$ , at 300 K, with a uniform distribution of donors. The results support the conclusion that at doping levels of  $2 \times 10^{19} \text{ cm}^{-3}$  or higher, the density of electronic states in silicon contains no contribution from localized bound impurity levels.

**20852.** Sattler, J. P.; Worchesky, T. L.; Maki, A. G.; Lafferty, W. J. Heterodyne frequency measurements on carbonyl sulfide near  $1050 \text{ cm}^{-1}$ , *J. Mol. Spectrosc.* 90, 460-466 (1981).

Key words: band centers; carbonyl sulfide; diode laser spectra; heterodyne frequency measurements; infrared spectroscopy; rotational constants.

Heterodyne techniques have been used to measure the frequency differences between carbonyl sulfide (OCS) absorption lines and  $\text{CO}_2$  laser transitions. A tunable diode laser was used both to scan the OCS absorption spectrum and to provide a beat signal against a  $\text{CO}_2$  laser. Frequency differences as great as 8.6 GHz were measured. Many different OCS hot-band transitions were measured near  $1050 \text{ cm}^{-1}$ , and the measurements on the  $02^0_0-00^0_0$  band have been extended to such high  $J$  levels ( $J=86$ ) that higher-order centrifugal distortion terms are needed to fit the data.

**20853.** Chiang, C. K.; Franklin, A. D. Electrical impedance spectra of trans-polyacetylene, *Solid State Commun.* 40, 775-779 (1981).

Key words: conductivity; electrical; impedance; polyacetylene; transport.

The electrical impedance spectra of trans-polyacetylene were studied. Using an equivalent circuit model, the impedance could be separated into two components. One component was identified as involving an intrinsic conduction which showed classical semiconductor behavior; the other component was identified as an inhomogeneity contribution. The results are discussed in terms of various transport experiments and models.

**20854.** O'Brien, T. C.; Franks, L. M. Evaluation framework for Federal technology transfer initiatives, *J. Technol. Transfer* 6, No. 1, 73-86 (1981).

Key words: evaluation; Federal R&D; industry; innovation; State and local governments; technology transfer; technology utilization.

Improved efforts to transfer the results of Federally-sponsored R&D to industry are cited often as an approach to help reverse declines in the rate of growth of U.S. industrial productivity and in the international competitiveness of certain industry sectors. As taxpayers and policy makers intensify their demands for accountability of public expenditures, technology transfer advocates must develop and apply analytic approaches which will measure the significant short and long-range impacts of Federally-sponsored programs, even though these impacts are especially difficult to measure directly.

This paper suggests a framework for evaluating Federal technology transfer in terms of short and long range goals and outputs. It outlines critical determinants of program success and suggests performance indicators through which results could be measured.

**20855.** Bennett, H. S.; Lowney, J. R. Effect of donor impurities on the density of states near the band edge in silicon, *J. Appl. Phys.* 52, No. 9, 5633-5642 (Sept. 1981).

Key words: bandgap narrowing; Bargmann potential; conduction states; donors; effective mass; energy dispersion; impurities; silicon; valence states; Yukawa potential.

Using the effective mass approximation and assuming that the scattering events for the electrons and holes by the assembly of donors are independent, we have calculated the effects of heavy doping on the conduction and valence states in silicon. When no bound-electron states associated with donors exist, the results show that: (1) the electron-donor interaction lowers the energy of the conduction and valence states, (2) band distortions occur, and (3) appreciable band-gap narrowing occurs. Our numerical results tend to support the band-gap estimates interpreted from optical measurements.

**20856.** Ruthberg, S. Graphical solution for the back pressurization method of hermetic test, *IEEE Trans. Components, Hybrids, Manuf. Technol.* CHMT-4, No. 2, 217-224 (June 1981).

Key words: back pressurization; electronic packages; hermetic test; leak testing.

The back pressurization method for leak-testing hermetically sealed electronic packages requires gas-flow modeling to relate indicated leakage rates to true leak size. The molecular flow relationship which is appropriate for fine leak sizes is nonlinear and requires a numerical solution, which in actual test application may involve either many trial calculations or the use of approximations that lead to limiting



case values. A new graphical procedure is presented for complete solution of the molecular flow equation for any given test condition and package volume through the use of a single set of characteristic curves and a test line. The effects of repetitive testing and of prefill with tracer gas are also considered. The characteristic curves are appropriate for both the helium leak detector and the radioisotope methods of test, while the form of the test line distinguishes between the two methods.

**20857.** Kovacs, W. D.; Leo, E. Cyclic simple shear of large scale sand samples: Effects of diameter to height ratio, *Proc. Int. Conf. Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics*, Apr. 26-May 3, 1981, III, 897-904 (University of Missouri-Rolla, Rolla, MO, 1981).

Key words: cyclic loading; dynamic test; laboratory test; sand; shear test; simple shear test; size effects.

Cyclic drained simple shear tests on a dry sand using a 12 in diameter sample with sample heights of 1, 2, and 4 in show the affect of Diameter/Height ratio on the shear modulus and percent of critical hysteretic damping at various shear strain levels. The shear modulus is found to increase with cycle number and with increasing specimen size. The D/H ratio is found to affect the shear modulus at low shear strains (<1 percent) and found to have little effect at higher shear strains and at failure. The hysteretic damping decreases for all values of shear strain tested (0.01 to 1 percent) as the cycle number and D/H ratio increases. Possible implications on design and pore pressure development are mentioned.

**20858.** Birky, M. M.; Clarke, F. B. Inhalation of toxic products from fires, *Bull. N.Y. Acad. Med.* 57, No. 10, 997-1013 (Dec. 1981).

Key words: alcohol; carbon monoxide; cigarettes; fatalities; fire; heart disease; heavy metals; hydrogen chloride; scenario.

A detailed fire-fatality study was carried out to determine the primary cause of death and the specific cause of fatality-producing fires. The study showed that: (1) the predominant cause of death is due to carbon monoxide, (2) a high percentage of the victims have elevated blood alcohol, (3) a significant number of fatalities had pre-existing cardiovascular disease, and (4) the predominant fatal fire scenario is the cigarette ignition of upholstered furniture or bedding with alcohol as a contributory factor.

Issues raised by the study and left unanswered include: (1) the relative significance of hydrogen cyanide and carbon monoxide, (2) the significance of antimony and other heavy metal found in the respiratory tract of victims as it relates to death and injury, (3) the significance of heavy soot deposits in the respiratory tract, and (4) the significance of sensory and pulmonary irritants such as HCl from vinyl materials and aldehydes.

**20859.** Koch, W. F.; Stolz, J. W. Analysis of chloride-doped cadmium sulfide by ion chromatography, *Anal. Chem.* 54, No. 2, 340-342 (Feb. 1982).

Key words: cadmium sulfide; chloride-doped cadmium sulfide; chlorine; hydrogen peroxide; ion chromatography; sulfur.

Cadmium sulfide, doped with chloride, is gaining increased attention as a possible superconductor at noncryogenic temperatures. Chemical composition and stoichiometry are critical parameters to the effectiveness of the compound for this use. Procedures are described for the characterization of chloride-doped cadmium sulfide for its anionic components. Alkaline hydrogen peroxide is used to dissolve the material and ion chromatography to profile and quantitate the anions. Data are presented showing the determination of total chlorine and sulfur, as well as extractable chloride and sulfate. Extension of the method to bromide-doped cadmium sulfide is proposed.

**20860.** Jach, T.; Powell, C. J. Incident-energy dependence of 3p electron energy-loss spectra of nickel, *Solid State Commun.* 40, 967-969 (1981).

Key words: electron energy-loss spectra; incident-energy dependence; nickel.

The intensities of two features in the 3p electron energy-loss spectrum of nickel, a dip prior to the threshold and a satellite ~12 eV

above the threshold, are observed to systematically decrease as the incident electron energy is lowered from 1000 to 150 eV. These intensity changes indicate a dependence of the matrix elements for each excitation on momentum transfer as the incident energy is decreased, in part through changes in the strength of Fano interference near threshold.

**20861.** Wasson, O. A.; Carlson, A. D.; Duvall, K. C. Measurement of the  $^{235}\text{U}$  neutron-induced fission cross section at 14.1 MeV, *Nucl. Sci. Eng.* 80, 282-302 (1982).

Key words: associated particle; fission cross section; uranium-235; 14 MeV neutron energy.

The  $^{235}\text{U}$  neutron-induced fission cross section was measured at a neutron energy of 14.1 MeV using the time-correlated associated-particle technique with the  $^3\text{H}(d,\alpha)n$  reaction at the National Bureau of Standards 3-MV Van de Graaff Laboratory. The areal density and total mass of the  $^{235}\text{U}$  deposits were measured relative to the standard  $^{235}\text{U}$  reference deposit (Los Alamos National Laboratory Spare Number 1) using thermal-neutron-induced fission counting. The total mass was also determined from the alpha-particle decay rate. The measured  $^{235}\text{U}$  cross section at  $14.1 \pm 0.1$  MeV is  $2.080 \pm 0.030$  b where the uncertainty is one standard deviation. This value agrees within 1% with other recent measurements using this technique and with the ENDF/B-V evaluation.

**20862.** Snyder, J. J. Fizeau wavemeter, (Proc. Los Alamos Conf. Optics, Los Alamos, NM, Apr. 7-10, 1981), *SPIE* 288, 258-262 (1981).

Key words: Fizeau; interferometer; laser wavelength meter; wavemeter.

The Fizeau Wavemeter is a real-time laser-wavelength measuring instrument intended for use with either pulsed or cw lasers. The instrument contains a static Fizeau interferometer which is illuminated by the laser. The fringe pattern of the interferometer is sampled by a 1024 element photodiode array and analyzed by a small computer to determine the wavelength of the illuminating laser. An earlier version of the instrument demonstrated a resolution of  $10^{-7}$  (about 50 MHz in the visible) at a read-out rate of 15 Hz, but suffered from systematic drifts in the calibration. Recent modifications in the software and in the optical system have virtually eliminated sensitivity to fringe amplitude non-uniformity and to wavefront curvature. Temperature sensitivity has been reduced to a level commensurate with the coefficient of thermal expansion of the interferometer spacer.

**20863.** Yates, J. T., Jr.; Goodman, D. W. Carbon monoxide chemisorption on Ni(100)—Direct detection of adsorbate-adsorbate interactions by desorption kinetic measurements, *J. Chem. Phys.* 73, No. 10, 5371-5375 (Nov. 15, 1980).

Key words: carbon monoxide; chemisorption; isotopic exchange; nickel; temperature programmed desorption.

The isotopic exchange between CO chemisorbed on Ni(100) and CO(g) has been studied using thermal desorption spectroscopy. Rapid isotopic exchange occurs at low crystal temperatures, and presumably involves low adsorption energy CO states which are present at high CO coverages on the Ni(100). Exchange is accompanied by rapid equilibration of exchanged CO throughout the entire CO layer.

**20864.** Tobler, R. L.; Read, D. T.; Reed, R. P. Strength/toughness relationship for interstitially strengthened AISI 304 stainless steels at 4 K temperature, (Proc. Fracture Mechanics: Thirteenth Conference, Philadelphia, PA, 1981), *Am. Soc. Test. Mater., Spec. Tech. Publ.* 743, pp. 250-268 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, 1982).

Key words: computer-aided mechanical tests; cryogenic mechanical properties; fracture (materials); fracture toughness; J-integral; low-temperature tests; stainless steels.

A study was conducted to determine the effects of carbon and nitrogen on the 4 K fracture properties of an Fe-18Cr-10Ni austenitic stainless steel having a base composition corresponding to AISI 304. J-integral fracture toughness tests using 24.5-mm-thick compact specimens (TL orientation) were performed in a liquid helium environment on nine steel heats having carbon plus nitrogen (C+N)



contents between 0.067 and 0.325 weight percent. The fracture toughness decreased with increasing C+N content. The  $K_{Ic}$  estimates obtained at 4 K ranged from 337 to 123 MPa·m<sup>1/2</sup>, exhibiting an inverse dependence on tensile yield stress. A computer-aided J-integral test facility was implemented to conduct this study. This new facility improves measurement accuracy, conserves material specimens and testing time, and systematizes test procedures.

**20865.** Wang, G. C.; Unguris, J.; Pierce, D. T.; Celotta, R. J. **PLEED study of temperature and hydrogen induced reconstruction and reordering of W(100)**, *Surf. Sci. Lett.* **114**, L35-L42 (Mar. 1982).

Key words: hydrogen chemisorption; PLEED; spin dependent electron scattering; temperature phases.

The structure of the high temperature (1×1), low temperature c(2×2), and hydrogen induced c(2×2)-H and (1×1)-H phases of W(100) were studied by polarized low energy electron scattering. At certain diffraction conditions the measured strength of the spin dependent scattering,  $S(E)$ , shows large differences between the various phases even though there are only slight changes in the measured intensity profiles,  $I(E)$ . The largest differences in  $S(E)$  were between the clean and hydrogen covered phases.

**20866.** Hardman, K.; Rhyne, J. J.; James, W. J. **Magnetic structures of  $Y_6(Fe_{1-x}Mn_x)_{23}$  compounds**, *J. Appl. Phys.* **52**, No. 3, 2049-2051 (Mar. 1981).

Key words: atomic ordering; iron; magnetism; manganese; yttrium.

Neutron diffraction studies of eleven compounds across the compositional range of the  $Y_6(Fe_{1-x}Mn_x)_{23}$  system reveal the presence of substantial preferential atomic ordering of Fe and Mn atoms on the four transition metal crystallographic sites. Throughout the entire compositional range, Mn atoms prefer to occupy the  $f_2$  site and Fe atoms the  $f_1$  site.

Neutron diffraction profile refinements show no long range magnetic ordering occurring in the compositional range from  $x=0.4$  to 0.75 as a consequence of the sharply reduced exchange interactions in the ternary compounds. The average Fe moments on each of the sites are reduced in the Fe-rich ternaries. The manganese atoms are nonmagnetic. In the Mn-rich ternaries the Fe atoms have no spontaneous moments and the Mn moments are decreased dramatically from  $Y_6Mn_{23}$ .

**20867.** Kovacs, W. D. **Results and interpretation of SPT practice study**, *ASTM Tech. Note GTJODJ 4*, No. 3, 126-129 (Sept. 1981).

Key words: drills; in situ test; penetration tests; practice; samplers; soil tests; standard penetration tests.

Geotechnical engineers in the United States commonly use the results of the ASTM Penetration Test and Split-Barrel Sampling of Soils (D 1586) in subsurface investigations for routine foundation design. Wide variations occur in standard penetration test (SPT) results because the present standard does not address some of the variables that control the energy delivered to the sampler. Current methods of performing the SPT in the United States were surveyed and the results are reported and interpreted. The purpose of the survey was to aid in bringing current practice to a more uniform state and to provide information for the next revision of ASTM D 1586.

**20868.** Ledbetter, H. M. **Elastic constants and internal friction of fiber-reinforced composites**, (Proc. Japan-U.S. Conf. Composite Materials, Tokyo, Japan, Jan. 12-14, 1981), Paper in *Composite Materials*, K. Kawata and T. Akasaka, eds., pp. 65-70 (The Japan Society for Composite Materials, Business Center for Academic Societies, Japan, 2-4-16, Bunkyo-ku, Tokyo 113, Japan, 1981).

Key words: boron-aluminum; elastic constants; glass-epoxy; graphite-epoxy; internal friction; shear modulus; sound velocity; ultrasonic wave; Young's modulus.

We review recent experimental studies at NBS on the anisotropic elastic constants and internal friction of fiber-reinforced composites. Materials that were studied include: boron-aluminum, boron-epoxy, graphite-epoxy, glass-epoxy, and aramid-epoxy. In all cases, elastic-constant direction dependence could be described by relationships developed for single crystals of homogeneous materials. Elastic

stiffness and internal friction were found to vary inversely.

**20869.** Younger, S. M. **Current theoretical problems in the electron impact ionization of positive ions**, *Comments At. Mol. Phys.* **11**, Nos. 3-5, 193-209 (1982).

Key words: atomic scattering theory; electron ionization of positive ions.

This report summarizes the main discussions of a workshop on the theory of electron ionization of atoms and ions held at the National Bureau of Standards in November, 1980. The applicability of partial wave methods to the ionization problem is discussed, as are several promising new theoretical approaches.

**20870.** Ederer, D. L.; Parr, A. C.; Cole, B. E.; Stockbauer, R.; Dehmer, J. L.; West, J. B.; Codling, K. **Vibrational-state dependence of partial cross sections and photoelectron angular distributions through autoionizing resonances: The  $n=3$  Rydberg state converging to the  $B^2\Sigma^+$  state of  $CO^+$** , *Proc. R. Soc. London, Ser. A* **378**, 423-435 (1981).

Key words: autoionizing resonances; photoelectron angular distributions; photon energy; Rydberg state.

The branching ratios for leaving the  $CO^+$  ion in a particular vibrational level of the ground  $X^2\Sigma^+$  state have been determined as functions of photon energy through the  $n=3$  autoionizing Rydberg state converging to the  $B^2\Sigma^+$  state of  $CO^+$ ; there are substantial differences between theoretical and experimental Franck-Condon factors when 'on' resonance. The branching ratios have been converted into absolute partial cross sections by normalizing to existing data obtained by using line sources. The asymmetry parameter  $\beta$  has also been determined for each vibrational level in this spectral range. Considerable variations in both have been observed in the region of this resonance.

**20871.** Gallagher, A. **The absorption and emission of radiation by the collision complex**, (Proc. XII Int. Conf. Physics of Electronic and Atomic Collisions, Gatlinburg, TN, July 15-21, 1981), Paper in *Physics of Electronic and Atomic Collisions*, S. Datz, ed., pp. 403-411 (North-Holland Publ. Co., Amsterdam, 1982).

Key words: line broadening; nitrogen; sodium.

The absorption and emission of radiation by interacting atoms has been used for many years to study atomic collisions. Generally called line broadening, it is actually a study of the diatomic collision complex. It is also a form of molecular spectroscopy, but it involves free rather than bound states, so it requires the study of intensity information rather than the wavelengths of bound-bound lines.

This field is now approaching a very exciting prospect of studying the collision complex in reactive collisions. It has long been recognized that the same ideas and principles normally applied to two interacting atoms can also be applied to an atom-molecule or triatomic interaction. However, the complexity is very much greater. Thus, whereas line broadening by two colliding atoms has been studied for many decades in many laboratories, triatomics are just beginning to be studied in only a few laboratories. Yet this type of measurement holds great promise as a powerful diagnostic of chemical reactions and other atom-molecule collision processes.

**20872.** Blubaugh, E. A.; Doane, L. M. **Vacuum thin-layer electrochemical cell for nonaqueous spectroelectrochemistry**, *Anal. Chem.* **54**, No. 2, 329-331 (Feb. 1982).

Key words: methyl viologen; nonaqueous; thin layer spectroelectrochemistry; vacuum.

A vacuum spectroelectrochemical cell for use with nonaqueous solvents is described. When used in conjunction with vacuum apparatus, the cell enables the preparation and maintenance of solutions in an oxygen and water-free environment. The cell is easily and rapidly converted from experiments in spectroelectrochemistry to use in thin layer or bulk electrochemistry. The electrochemistry and spectroelectrochemistry of methyl viologen in propylene carbonate is examined.

**20873.** Takagi, S.; Mathew, M.; Brown, W. E. **Water-rich hydrates. The structures of dimagnesium potassium hydrogenbis(arsenate) 15-hydrate and dimagnesium potassium hydrogenbis(phosphate) 15-**



Key words: crystal structure; hydration of  $\text{XO}_4$  ion; magnesium arsenate hydrate; magnesium phosphate hydrate; struvite analogue; water-rich hydrates.

The crystal structures of two isomorphous salts of the type  $\text{Mg}_2\text{KH}(\text{XO}_4)_2 \cdot 15\text{H}_2\text{O}$ , where  $\text{X}=\text{As}$  (I) and  $\text{X}=\text{P}$  (II), have been determined by single-crystal X-ray diffraction. The crystals are triclinic, space group  $P\bar{1}$ , with cell dimensions  $a=6.390$  (2),  $b=12.477$  (3),  $c=6.659$  (2) Å,  $\alpha=93.54$  (2),  $\beta=88.71$  (2) and  $\gamma=94.51$  (2)° for (I) and  $a=6.288$  (1),  $b=12.228$  (1),  $c=6.554$  (1) Å,  $\alpha=93.64$  (1),  $\beta=89.18$  (1) and  $\gamma=94.69$  (1)° for (II). The structures were refined by full-matrix least-squares techniques to  $R=0.079$  and  $0.035$  using 964 and 2633 non-zero reflections for (I) and (II) respectively. The two crystallographically independent  $\text{Mg}^{2+}$  ions are coordinated to six water molecules. The acidic H atom appears to be involved in a symmetrical hydrogen bond forming a dimeric  $[\text{H}(\text{XO}_4)_2]$  unit. The  $[\text{H}(\text{XO}_4)_2]$  unit is completely surrounded by water molecules. Each O atom of  $\text{XO}_4$  is involved in three hydrogen bonds. The structure can be described in terms of interpenetrating layers with two open channels. These channels are randomly occupied by a  $\text{K}^+$  ion and a water molecule. Relationships with other struvite-type compounds are discussed.

**20874.** Coursey, B. M.; Hoppes, D. D.; Schima, F. J. Determination of the photon emission rates of the NBS long-lived mixed-radionuclide standard, *Nucl. Instrum. Methods* **193**, 1-8 (1982).

Key words: calibration of gamma-ray detector efficiencies; emission-rate measurements; gamma-ray spectrometry; germanium-detector efficiencies; long-lived-mixed radionuclide standard; uncertainties in gamma-ray measurements.

A mixture of  $^{125}\text{Sb}$ ,  $^{154}\text{Eu}$ , and  $^{155}\text{Eu}$  has been used to prepare gamma-ray emission-rate standards with a functional life of over 10 years and with useful photon emissions at over 18 energies between 25 and 1600 keV. The standards are useful for the calibration of the efficiency of germanium gamma-ray detectors in this energy range. Correlated summing corrections are moderate, compared to many radionuclides which provide multiple calibration points. Photon-emission rates for the major radiations have been measured, for sources quantitatively related to the standards, with four germanium spectrometer systems especially calibrated for the purpose. For two coaxial detectors, efficiency values were established at 28 energies between 88 and 2800 keV, with an average total uncertainty, estimated at a level corresponding to a standard deviation of the mean, of about 0.6%. At lower energies, the most reliable calibration points were given by X- or gamma-rays directly measured with defined-geometry NaI(Tl) systems. Calculated efficiency curves were used for interpolation between these points. Significant efficiency changes of the coaxial detectors with time were monitored and accounted for. The emission rates of selected X-rays and gamma-rays from the standards are specified with total uncertainties of from 0.6% to 1.3%, estimated to correspond to one standard deviation of the mean.

**20875.** Moldover, M. R. Defining critical point experiments for a space laboratory, (Proc. Workshop on Spacecraft Dynamics as Related to Laboratory Experiments in Space, Marshall Space Flight Center, Huntsville, AL, May 1-2, 1979), *NASA Conf. Publ.* **2199**, 11-17 (1981).

Key words: critical phenomena in space; critical point; dielectric constant; gravity effects; light scattering.

We are defining three representative low gravity experiments for a fluid near its liquid-vapor critical point. Two of these experiments require very careful measurements of properties of the fluid in thermodynamic equilibrium while the third experiment is a series of optical observations of the phenomena which occur as a fluid is changed from one phase to two phases, either by cooling through the critical point or by adiabatic expansion. We are concerned with spacecraft dynamics insofar as residual spacecraft motions may complicate the interpretation of the data from the proposed experiments. It is possible that the spacelab environment will render certain desirable experiments impractical.

**20876.** DeCandia, F.; Russo, R.; Vittoria, V.; Peterlin, A. Mechanical

and transport properties of drawn crosslinked low-density polyethylene, *J. Polym. Sci., Polym. Phys. Ed.* **20**, No. 2, 269-277 (1982).

Key words: concentration coefficient of diffusivity; density; diffusion coefficient; drawing stress; low density polyethylene; plastic deformation; sorbate concentration; sorption; weight gain.

The values of drawing dependence of the density  $\rho$ , axial elastic modulus  $E$ , and maximum draw ratio  $\lambda$  of crosslinked low-density polyethylene (CLPE) rather similar to those obtained with uncrosslinked branched material of similarly low density. Very much the same applies to the equilibrium concentration of sorbed methylene chloride in the amorphous component and the zero-concentration diffusion coefficient  $D_0$ . The exponential concentration coefficient  $\gamma_D$ , however, even at the maximum draw ratio, shows no indication of the rapid increase so characteristic of the completed transformation from the lamellar to the fibrous structure. On the basis of this finding, one can understand the small deviations in the dependence of the mechanical properties between the crosslinked and uncrosslinked branched material. The segments between the crosslinks, much shorter than the free molecules, favor the formation of the interfibrillar tie molecules that limit the drawability of the sample. But since they cannot be extended to the same length as the free molecules, they contribute less to the total fraction of tie molecules per amorphous layer and hence yield a smaller axial elastic modulus.

**20877.** Sugar, J.; Kaufman, V. Ag I isoelectronic sequence: Wavelengths and energy levels for Ce XII through Ho XXI and for W XXVIII, *Phys. Scr.* **24**, No. 4, 742-746 (1981).

Key words: Ce; energy levels; Eu; Gd; Ho; Nd; Pr; Sm; Tb; wavelength.

An earlier analysis of the spectra of Ce XII, Pr XIII, Nd XIV, and Sm XVI has been significantly expanded. Wavelengths are presented for the first time for Eu XVII through Ho XXI. Spectra of Ce XII through Ho XXI were obtained with a high voltage triggered spark and photographed on the NBS 10.7 m grazing incidence spectrograph. Observations of tungsten in the plasma of the Oak Ridge tokamak (ORMAK) were transmitted to us. Energy levels of configurations of the type  $4d^{10}nl$  and  $4d^94f$  are derived for each ion and for W XXVIII. Ionization energies are derived through Eu XVII by means of the  $ns$  series.

**20878.** Wyart, J. F.; Kaufman, V. Extended analysis of doubly ionized thorium (Th III), *Phys. Scr.* **24**, No. 6, 941-952 (1981).

Key words: actinide; energy; energy levels; ionization parametric interpretation; thorium; wavelengths.

The sliding spark spectrum of thorium has been observed and measured in the range 500-1500 Å. This has led to the classification of 488 lines as transitions between 98 new levels and 77 previously known levels of Th III. Ninety-two previously observed lines above 1940 Å are now classified. The configurations  $5f6d$ ,  $5f^2$ ,  $5f7d$  and  $5f8s$  are complete and the main features of  $5f6f$ ,  $6d7d$ ,  $5f8p$  and  $6d6f$  are described. All of these configurations have been interpreted by means of the Slater-Condon theory and the ionization energy of doubly-ionized thorium has been derived from the  $5fns$  series:  $147\,800 \pm 400 \text{ cm}^{-1}$  ( $18.33 \pm 0.05 \text{ eV}$ ).

**20879.** Casella, R. C. Detection of impurity tunneling in solids via coherent phonon coupling and direct neutron scattering, (Proc. Int. Conf. Phonon Physics, Bloomington, IN, Aug.-Sept. 1981), *J. Phys. Colloq.* **C6**, 42, No. 12, C6-923-C6-925 (Dec. 1981).

Key words: hydrogen in metals; impurity tunneling;  $\text{KBr:CN}^-$ ;  $\text{KCl:CN}^-$ ; neutron scattering; phonon coupling; theory.

A theoretical treatment is given of the observation of molecular tunneling in solids by the coherent interaction of the tunnel-split excitations with acoustic phonons and by direct neutron inelastic scattering. Results are applied to the case of rotation tunneling of  $\text{CN}^-$  dumbbells in KBr and KCl, and to the motion of H atoms in two-well traps associated with oxygen impurities in niobium. Comparison is made with experiment.

**20880.** Roszman, L. J. Dielectronic recombination in collision of electrons with multicharged ions, (Proc. XII Int. Conf. Physics of



Electronic and Atomic Collisions, Gatlinburg, TN, July 15-21, 1981), Paper in *Physics of Electronic and Atomic Collisions*, S. Datz, ed., pp. 641-653 (North-Holland Publ. Co., New York, 1982).

Key words: autoionization; collisions; dielectronic recombination; multicharged ions; scattering.

This paper was one of the invited papers of the XII International Conference on the Physics of Electronic and Atomic Collisions, held at Gatlinburg, Tennessee, July 15-21, 1981.

**20881.** Kruger, J. Fundamental aspects of the corrosion of metallic implants, *Am. Soc. Test. Mater., Spec. Tech. Publ. 684*, pp. 107-127 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, 1979).

Key words: corrosion; crevice corrosion; galvanic corrosion; implant materials; implants; passivity; pitting.

The corrosion of metals in the aqueous environments of body fluids involves the setting up of electrochemical corrosion cells. The corrosion produced by these cells is controlled by thermodynamic and kinetic factors. The thermodynamic factors determine the corrosion tendencies; the kinetic factors determine the rate. Galvanic corrosion is affected by both thermodynamic and kinetic factors and occurs when two metals with widely differing potentials are placed in contact with each other. Other forms of corrosion depend more directly on factors controlling the rate of corrosion. For most alloys used in implants the corrosion rate is mainly dependent on the protective properties of the thin passive films that exist on the surfaces of these alloys. The quality of the protection afforded by passive films is related to their ability to resist chemical breakdown by damaging species and, once broken down, their ability to reform rapidly (repassivate). The interplay between breakdown and repassivation is important in determining the susceptibility of metallic implants to pitting, crevice corrosion, stress corrosion, corrosion fatigue, intergranular corrosion, and fretting corrosion.

**20882.** Kruger, J. Dissolution of passive films on iron in nearly neutral solutions, (Proc. Int. Symp. Honoring Prof. H. H. Uhlig on his 75th Birthday, R. P. Frankenthal and F. Mansfeld, eds., 1981), Paper in *Corros. Corros. Prot.* 81-8, 66-76 (The Electrochemical Society, Inc., 10 South Main Street, Pennington, NJ 08354, 1981).

Key words: anodic oxidation; dissolution of passive films; ellipsometry; iron; passive films; potentiostat.

A description is given of a study of the dissolution of passive films formed by potentiostatic anodic oxidation of iron in sodium borate-boric acid solutions. Using an ellipsometric-potentiostatic technique, four different potential regions were identified where different dissolution behavior could be observed. Two different dissolution modes were found at potentials in the passive region; one dissolution mode at potentials at or slightly below the Flade potential, and one mode at potentials where cathodic reduction becomes possible.

**20883.** Mann, W. B.; Hutchinson, J. M. R.; Edgerly, D. E. National and international traceability in radioactivity measurements, (Proc. Symp. Methods of Low-Level Counting and Spectrometry, Berlin, West Germany, June 10, 1981), Paper in *Methods of Low-Level Counting and Spectrometry*, pp. 173-187 (International Atomic Energy Agency, Vienna, Austria, 1981).

Key words: environmental measurements; international quality assurance; national quality assurance; natural-matrix reference materials; radioactivity measurements; radiopharmaceuticals; traceability.

The quality of radioactivity measurements in this period of rapidly expanding production and use of radioactive materials and their transfer to the biosphere has come under increasing scrutiny from government regulatory agencies and the public alike. This paper reviews the history and present status of measurements assurance, or traceability, programmes developed in the United States of America to ensure the quality of such measurements. It also briefly describes intercomparative measurements carried out with other national laboratories either directly or through the Bureau International des Poids et Mesures and the International Atomic Energy Agency for the purpose of establishing traceability in the international field. It is concluded that in the USA it is logistically impossible, except in a few

special cases, for the National Bureau of Standards to provide other than programmes that will give implicit quality assurance for radioactivity measurements.

**20884.** Datta, S. K.; Ledbetter, H. M.; Kinra, V. K. Wave propagation and elastic constants in particulate and fibrous composites, (Proc. Japan-U.S. Conf. Composite Materials, Tokyo, Japan, Jan. 12-14, 1981), Paper in *Composite Materials*, K. Kawata and T. Akasaka, eds., pp. 30-38 (The Japan Society for Composite Materials, Business Center for Academic Societies, Japan, 2-4-16, Bunkyo-ku, Tokyo 113, Japan, 1981).

Key words: composites; elastic constants; elastic-wave scattering; fiber-reinforced composites; particulate composites; wave propagation.

For two types of composites—particulate and fiber-reinforced—dynamic elastic properties were studied both theoretically and experimentally. The two composites contained, respectively, randomly distributed spherical inclusions and aligned continuous fibers, both in a homogeneous matrix. The theory describes aligned, identical ellipsoidal inclusions. As special cases, the theory comprises both spherical inclusions and short fibers. Bose and Mal presented previously a similar theory for continuous fibers. The theories estimate the effective propagation speed of a plane harmonic wave; the theories average the scattered field by the Waterman-Truell procedure and use the Lax quasi-crystalline approximation. Theory and observation agree quite well. Particulate composites were studied in a through-transmission water-immersion tank, while the fiber composite was studied by both pulse-echo-overlap and resonance methods.

**20885.** Larsen, E. B. Background and present status of NBS research on isotropic E-field probes, (Proc. IEEE Int. Symp. Electromagnetic Compatibility, Rising to Greater Heights, Boulder, CO, Aug. 18-20, 1981), *IEEE Trans. Electromagn. Compat. No. 81CH1675-8*, pp. 434-438 (IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854, 1981).

Key words: electromagnetic field; field intensity meter; isotropic antenna; radio frequency radiation.

A discussion is given of past rf probe development work at NBS. A new radiation monitor (EFM-5) is described which has good isotropy over a 60 dB dynamic range (1 to 1000 V/m). The frequency range for flat response (within  $\pm 2$  dB) is 0.2 to 1000 MHz. Electronic circuitry obtains the "total magnitude" of all field polarizations and frequency components. The special features, performance and essentials of design are given. The needs and direction of future probe research at NBS are also discussed. This paper emphasizes the background and early research on rf probes at NBS.

**20886.** Bertocci, U. AC induced corrosion. The effect of an alternating voltage on electrodes under charge-transfer control, *Corrosion* 35, No. 5, 211-215 (May 1979).

Key words: alternating voltage; charge-transfer; corrosion; electrochemistry; frequency analysis; rectification.

The equation relating current to voltage for an electrode under charge-transfer control has been solved for a sinusoidal modulation of the electrode potential. The rectified Faradaic component has been obtained, so as to derive its value as a function of the Tafel parameter and of the amplitude of the modulating voltage, as well as of average electrode potential. The case where one electrode reaction is under diffusion control also has been treated. The amplitude and phase characteristics of the harmonic components have been derived, and their use for determining the kinetic properties of the electrode have been discussed. The capacitive current generated by the alternating voltage also has been investigated, and the conditions under which it can be separated from the Faradaic current have been given. The implications of these results on the corrosion due to AC leakage have been examined.

**20887.** Kuriyama, M. Residual stress measurements using energy dispersive diffractometry and high energy incident photons, *Proc. Symp. Nondestructive Measurement of Wheel/Axle Residual Stress, Cambridge, MA, June 16-17, 1981*, pp. 2.10.1-2.10.13 (U.S. Department of Transportation, Federal Railroad Administration, Cambridge, MA, 1981).



Key words: energy dispersive diffractometry; high energy photons; residual stress.

The application of energy dispersive diffractometry using high energy photons (up to 200 keV) to monitor the structural integrity of industrial materials is described. X-ray optical conditions and counting statistics are studied in several transmission experiments using commercial steel plates almost one inch (2.5 cm) thick. A residual stress distribution across a weld zone in an Alaskan pipe line segment is obtained by the energy dispersive diffractometry method. This result demonstrates the potential capability of this technique as an industrial inspection tool to predict flaws and cracks in materials with a given precision and in a nondestructive manner.

**20888.** Collé, R. **Reporting of environmental radiation measurement data**, (Proc. 11th Annu. Conf. Radiation Control, Oklahoma City, OK, May 6-10, 1979), Paper in *HHS Publication (FDA) 81-8054, Radiological Health*, pp. 342-358 (Department of Health and Human Services, Public Health Services, Food and Drug Administration, Washington, DC, 1981).

Key words: data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; units.

Based on an interagency and multi-organizational project coordinated by NBS, recommendations for a uniform method of data reporting are presented and justified. Three primary requisites are considered: proper units, an appropriate number of significant figures, and an unambiguous statement of measurement uncertainty. Guidelines are given for estimating random and systematic uncertainties, and for propagating and combining them to form an overall uncertainty. It is recommended that each reported measurement result include the value, the total random uncertainty expressed as the standard deviation, and the combined overall uncertainty. To avoid possible biases of data, all measurement results should be reported directly as obtained, including negative values. The lower limit of detection (LLD) should serve only as an *a priori* estimate of detection capability for the instrumentation, and not as an absolute level of activity that can or cannot be detected. The concept of a minimum detectable concentration (MDC) is introduced to serve as an *a priori* estimate of the capability for detecting an activity concentration by a given measurement instrument, procedure, and type of sample. Neither the LLD nor the MDC is intended to be an *a posteriori* criterion for the presence of activity.

**20889.** Ettinger, K. V.; Nam, J. W.; McLaughlin, W. L.; Chadwick, K. H. **Progress in high-dose radiation dosimetry**, (Proc. Int. Atomic Energy Agency and World Health Organization Symp., Paris, France, Oct. 1980), Invited paper in *Biomedical Dosimetry: Physical Aspects, Instrumentation and Calibration*, pp. 405-432 (International Atomic Energy Agency, Vienna, Austria, 1981).

Key words: alanine; biographic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; radiochromic dye.

The last decade has witnessed a deluge of new high-dose dosimetry techniques and expanded applications of methods developed earlier. Many of the principal systems are calibrated by means of calorimetry, although production of heat is not always the final radiation effect of interest. Reference systems also include a number of chemical dose meters: ferrous sulphate, ferrous-cupric sulphate, and ceric sulphate acidic aqueous solutions. Requirements for stable and reliable transfer dose meters have led to further developments of several important high-dose systems: amino acids and saccharides analysed by ESR or lyoluminescence, thermoluminescent materials, radiochromic dyes and plastics, ceric-cerous solutions analysed by potentiometry, and ethanol-chlorobenzene solutions analysed by high-frequency oscillometry. A number of other prospective dose meters are also treated in this review. In addition, an IAEA programme of high-dose standardization and intercomparison for industrial radiation processing is described.

**20890.** Dufty, J. W.; Lindenfeld, M. J.; Garland, G. E. **Kinetic models**

for the generalized Enskog equation, *Phys. Rev. A* **24**, No. 6, 3212-3225 (Dec. 1981).

Key words: Enskog equation; hard sphere gas; kinetic models.

The generalized Enskog equation is used to describe the dynamic structure factor  $S(k, \omega)$  for a hard-sphere gas. The problem of constructing kinetic models for the calculation of  $S(k, \omega)$  is considered and the minimum set of matrix elements of the exact collision operator required by hydrodynamics is identified. The source of existing discrepancies between kinetic-model calculations and light-scattering experiments is also found and removed. Sensitivity of  $S(k, \omega)$  to the parameters of kinetic models is discussed and a simple model proposed. A preliminary comparison of the hard-sphere  $S(k, \omega)$  calculated from this model with neutron-scattering data from gaseous krypton is given.

**20891.** Celotta, R. J.; Pierce, D. T.; Kelley, M. H.; Rogers, W. T. **Polarized electrons**, (Proc. XII Conf. Physics of Electronic and Atomic Collisions, Gatlinburg, TN, July 15-21, 1981), Paper in *Physics of Electronic and Atomic Collisions*, S. Datz, ed., pp. 545-555 (North-Holland Publ. Co., New York, 1982).

Key words: electron polarization; electron scattering resonances; spin; spin-orbit interaction; surface magnetism.

Previous papers on this topic at ICPEAC and ICAP have described clever techniques for producing polarized electron beams, novel experiments that could be performed if sufficient beam intensity were available, and a number of promising experiments skillfully completed with the huge effort necessary to overcome the inefficient processes of producing and detecting electron spin polarization. The spirit of these papers is well summarized in the concluding remarks of Ob'edkov in his paper on this subject, presented at the last ICPEAC: "It is easy to continue the list of problems where the application of polarized electrons could give unique information, which is unthinkable to get by any other way... further progress first of all depends on the success of experimental research which will stimulate theoretical work in the different fields." We report here on recent experimental advances, coming primarily from the rapidly developing area of surface physics, that have given us the technology necessary to obtain this long sought information. After describing the two main spin dependent effects, the spin-orbit and exchange interactions, we describe the GaAs polarized electron source. We then illustrate its usefulness with studies of the spin-orbit and exchange interactions on solid surfaces and, in both cases, describe new, and promising ways of measuring electron polarization. Finally, we offer our view of the prototype future electron-atom collision experiment, including full quantum state selection.

**20892.** Reeve, G. R.; Wainwright, A. E. **A frequency tracking, tuned, receiving monopole**, (Proc. 1981 Int. Symp. Antennas and Propagation, Los Angeles, CA, June 16-19, 1981), *IEEE Conf. Rec. 81CH1672-5, 1981 Int. Symp. Dig.*, **2**, 578-581 (IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854, 1981).

Key words: active; antenna; filter; monopole; tracking; tuneable.

This summary paper describes an active receiving antenna which is tuned to the receiving frequency. Tuning is accomplished by variable capacitive diodes and can be tracked to the receiving system over octave ranges. This results in reduced intermodulation distortion and improved rejection of out of band signals.

**20893.** Wlodawer, A.; Bott, R.; Sjölin, L. **The refined crystal structure of ribonuclease A at 2.0 Å resolution**, *J. Biol. Chem.* **257**, No. 3, 1325-1332 (Feb. 10, 1982).

Key words: active site; charge relay; enzymes; protein structure; ribonuclease; x-ray diffraction.

This paper describes the structure of bovine pancreatic ribonuclease A, refined by a restrained parameter least squares procedure at 2.0 Å resolution, and rebuilt using computer graphics. The final agreement factor  $R = \sum |F_o| - |F_c| / \sum |F_o|$  is 0.159. The positions of the 951 main chain atoms have been determined with an estimated accuracy of 0.17 Å. In addition, the model includes a phosphate group in the active site and 176 waters, many of them with partial occupancy. The bond lengths in the refined structure of RNase A differ from the ideal values by an overall root mean square deviation of 0.022 Å; the



corresponding value for angle distances is 0.06 Å. The root mean square deviation of planar atoms from ideality is 0.017 Å, and root mean square deviation of the peptide torsion angles from 180° is 3.4°. The model is in good agreement with the final difference Fourier maps.

Two active site histidines, His 12 and His 119, form hydrogen bonds to the phosphate ion. His 119 is also hydrogen bonded to the carboxyl of Asp 121 and His 12 to the carbonyl of Thr 45. The structure of the RNase A is very similar to that of RNase S, particularly in the active site region. The root mean square discrepancy of all atoms from residues 1 to 16 and 24 to 123 is 1.06 Å and the root mean square discrepancy for the active site region is 0.6 Å.

**20894.** Loevinger, R. Calculation of absorbed dose in high-energy photon and electron beams using a calibrated ionization chamber, (Proc. Int. Symp. Biomedical Dosimetry: Physical Aspects, Instrumentation, Calibration, jointly organized by the Int. Atomic Energy Agency and the World Health Organization, Paris, France, Oct. 27-31, 1980), Invited paper *IAEA-SM-249/93*, pp. 283-296 (International Atomic Energy Agency, Vienna, Austria, 1981).

Key words: absorbed dose; calibration; electron beam; high energy; ionization chamber; photon beam; radiation therapy.

Conventional methods of obtaining absorbed dose for radiation therapy in a high-energy beam make use of ionization chambers calibrated in terms of exposure, and are generally described as the  $C_A$  and  $C_E$  methods. It is known that these methods contain at least small errors due to neglect of the individual properties of the ionization chambers. Calibration is now provided at various standards laboratories in terms of exposure, air kerma, and absorbed dose to water. A method of calculation is described that can start with a calibration in terms of any one of these three quantities, and that (at least in principle) accounts for properties of the ionization chamber, the surrounding medium, and the high-energy beam.

**20895.** Alefeld, B.; Anderson, I. S.; Heidemann, A.; Magerl, A.; Trevino, S. F. The measurement of tunnel states in solid  $\text{CH}_3\text{NO}_2$  and  $\text{CD}_3\text{NO}_2$ , *J. Chem. Phys.* 76, No. 5, 2758-2759 (Mar. 1, 1982).

Key words: deuterated; methyl group; neutron scattering; nitromethane; reorientation; tunnel states.

The splitting of the ground librational state of the methyl group in  $\text{CH}_3\text{NO}_2$  and  $\text{CD}_3\text{NO}_2$  in the solid has been measured by inelastic neutron scattering. The value of the splitting is 35  $\mu\text{eV}$  in  $\text{CH}_3\text{NO}_2$  and 1.7  $\mu\text{eV}$  in  $\text{CD}_3\text{NO}_2$ .

**20896.** Wright, R. N. Building-related research of the U.S. National Bureau of Standards, *Proc. Latin American Symp. Rational Organization of Building Applied to Low-Cost Housing, Sao Paulo, Brazil, Oct. 28, 1981*, pp. 335-347 (Instituto de Pesquisas Technologicas do, Estado de S. Paulo S/A Cidade Universitaria, 05508, Sao Paulo, Brazil, 1981).

Key words: building research; equipment research; fire research; geotechnical research; illumination; structural research; thermal performance.

Building-related research and technology transfer activities at the U.S. National Bureau of Standards (NBS) are described to: assist Latin American housing and building organizations formulate building practices effective for their particular needs, provide access to potentially useful NBS research results, and identify opportunities for cooperative studies with NBS. The Performance Concept (which relates building practices explicitly to qualities required for usefulness, safety and economy) guides NBS building research. Fundamental research makes clearer and more explicit the causes and consequences of building performance qualities and provides the foundations for sustained, cumulative improvements in building practices. Practical measurement technology is developed to assist the building community in achieving intended performance qualities. Links to intermediary organizations in the building community (professional societies, trade associations, standards organizations and governmental agencies) allow a relatively small building research organization to be cognizant of the most important technical problems facing the building community, to work with other organizations to make contributions to the improvement of building practices, and to achieve application of research results in the building community.

**20897.** Heinrich, K. F. J. Microanalysis and microscopy: An overview, (Proc. 1981 Natl. Conf. Microbeam Analysis Society, Vail, CO, July 13-17, 1981), *Anal. Electron Microsc.*, R. H. Geiss, ed., pp. vi, 1-10 (San Francisco Press Inc., 547 Howard Street, San Francisco, CA 94105, 1981).

Key words: electron microscopy; electron probe microanalysis; ion probe; laser Raman probe; microanalysis; microscopy.

Microanalysis by physical techniques has replaced the chemical technique of elementary microanalysis by chemical techniques. The microbeam techniques used at present are closely related to and complementary to microscopic procedures. The techniques of microscopy and microanalysis thus converge into a single group of techniques for materials characterization.

**20898.** FitzGerrell, R. G. Free-space transmission loss for anechoic chamber performance evaluation, (Proc. IEEE Int. Symp. Electromagnetic Compatibility, "Rising to Greater Heights," Boulder, CO, Aug. 18-20, 1981), *IEEE Trans. Electromagn. Compat. Cat. No. 81CH1675-8*, pp. 110-111 (IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854, 1981).

Key words: anechoic chamber; calibrations; reflection errors.

A longitudinal probe scan of an anechoic chamber yields a plot of measured transmission loss. Any deviation of this curve from calculated free-space transmission loss can be attributed to chamber reflections or, at small separation distances, to finite-range source antenna gain corrections or to source-probe interactions.

**20899.** Sengers-Levelt, A. Overeenstemmende toestanden en universaliteit bij het kritieke punt, *Nederlands Tijdschrift voor Natuurkunde* A47, No. 4, 137-143 (1981).

Key words: corresponding states; critical point universality; liquefaction of helium; mechanical equivalence; mixtures; molecular potential; quantum parameter.

The history of the law of corresponding states is traced; early achievements—liquefaction of helium and van der Waals' theory of mixtures—are discussed. The justifications for corresponding states—the principle of mechanical equivalence and, later, the statistical mechanical one, are discussed. The first generalization of the principle as the quantum mechanical law of corresponding states of de Boer.

Its importance, and the example it set for other generalizations is discussed. Finally, the modern principle of critical-point universality is introduced, and it is shown that it supplements, rather than replaces, the principle of corresponding states.

**20900.** DeGraff, E.; McLaughlin, W. L. Quality control for electron beam processing of polymeric materials by end-point analysis, (Proc. 3d Int. Meet. Radiation Processing, Tokyo, Japan, Oct. 26-30, 1980), Paper in *Radiat. Phys. Chem.* 18, No. 5-6, 975-985 (Pergamon Press, Oxford, 1981).

Key words: crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon.

Properties of certain plastics, e.g., polytetrafluoroethylene, polyethylene, ethylene vinyl acetate copolymer, can be modified selectively by ionizing radiation. One of the advantages of this treatment over chemical methods is better control of the process and the end-product properties. The most convenient method of dosimetry for monitoring quality control is post-irradiation evaluation of the plastic itself, e.g., melt index and melt point determination. It is shown that by proper calibration in terms of total dose and sufficiently reproducible radiation effects, such product test methods provide convenient and meaningful analyses. Other appropriate standardized analytical methods include stress-crack resistance, stress-strain-to-fracture testing and solubility determination. Standard routine dosimetry over the dose and dose rate ranges of interest confirm that measured product end points can be correlated with calibrated values of absorbed dose in the product within uncertainty limits of the measurements.



**20901.** Taggart, H. E.; Shafer, J. F. **Fixed and base station antennas**, *NIJ Standard-0204.01*, 19 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, 1977).

Key words: antenna; base station; fixed antennas; law enforcement; performance standard; radiation pattern; relative antenna gain.

This standard is a voluntary performance standard for evaluating antennas used at base stations and other fixed sites. It is intended for use by law enforcement agencies and others as an aid in the selection and procurement of this type of antenna. The standard includes the most commonly used definitions, minimum performance requirements, most critical items of test equipment, and methods of test needed to determine the effectiveness and suitability of these antennas for law enforcement use. Parameters tested include antenna power rating, relative antenna gain, and the antenna vertical and horizontal radiation pattern.

This standard is a revision of NILECJ-STD-0204.00 dated November 1977. This revision expands the standard to include antennas used in the 800-960 MHz frequency band and to include the design and construction details of two types of reference antennas.

**20902.** Rativanich, N.; Radak, B. B.; Miller, A.; Uribe, R. M. **Liquid radiochromic dosimetry**, (Proc. 3d Int. Meet. Radiation Processing, Tokyo, Japan, Oct. 26-30, 1980), Paper in *Radiat. Phys. Chem.* 18, No. 5-6, 1001-1010 (Pergamon Press, Oxford, 1981).

Key words: dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate.

By strategic combination of weak acid, mild oxidizing agent, and polar organic solvents containing millimolar concentrations of leucocyanides of certain triphenylmethane dyes, fairly broad ranges of absorbed doses of ionizing radiation can be determined. The yield of dye ions as determined by spectrophotometry can be made essentially constant with dose (i.e., linear response) from 0.01 to 30 kGy, and it does not vary with dose rate up to  $10^{11}$  Gy·s<sup>-1</sup>. The radiation-induced color is stable and offers fast-retrieval dosimetry if N-vinyl-2-pyrrolidone is used as solvent. Other possible polar solvents are 2-propanol, 2-methoxy ethanol, N, N-dimethyl formamide, dimethyl sulfoxide, and triethyl phosphate. Dimethyl sulfoxide is found to give the widest and most linear response. Suitable dye precursors are leucocyanides of pararosaniline, new fuchsin, hexa (hydroxyethyl) pararosaniline, crystal violet, malachite green, setoglauine, ethyl violet, helvetia green, basic violet-14, and formyl violet. Low concentrations of carboxylic acids contribute stability to the system. Typical mild oxidizing agents are nitrobenzene, and atmospheric oxygen, or oxygen released radiolytically from the solvents. The dosimetry systems do not require high-purity of ingredients or ultracleanliness of containers, although, for reproducibility of dye yields (G-values), thoroughly purified and uniform dye derivatives are recommended.

**20903.** Park, C. **Single-zone computer model for residential furnace location analysis**, (Proc. ASHRAE 1981 Annu. Meet., Cincinnati, OH, June 28-July 1, 1981), *ASHRAE Trans.* 87, Pt. 2, 897-920 (1981).

Key words: burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; residential furnaces; room temperature; thermal response factors; thermostat control.

A computer model has been constructed to determine in situ performance of a fossil fuel-fired residential furnace. This single zone model deals with both the cases when the furnace is within the zone or outside of the zone.

Based upon existing computer models such as NBSLD and DEPAF, a dynamic simulation model is developed to analyze the dynamic interaction of a heating unit, a thermostat, and a building envelope. Room air temperature is evaluated every minute while the excitation of outdoor air temperature is considered every 30 minutes. Thermal behavior of the furnace is evaluated every 5 seconds. Two kinds of thermal response factors of the structure incorporate with heat balance equations.

Simulation results of indoor installation are compared with experimentally measured values. Good agreement is obtained. Energy

consumptions for indoor and outdoor installations are compared. This computer model may serve as a vehicle for sensitivity analysis due to the furnace configuration, the thermostat settings, and the building structure changes.

**20904.** Taggart, H. E.; Jeffers, F. F.; Jickling, R. F.; Nelson, R. E.; Saulsbery, L. F.; Sugar, G. R. **Control heads and cable assemblies for mobile FM transceivers**, *NIJ Standard-0216.00*, 13 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Dec. 1981).

Key words: cable assembly; cable connector; control cable; control head; D-subminiature connector; interchangeability; law enforcement; microphone cable; mobile transceiver; performance standard.

This document is a voluntary performance standard that identifies characteristics, establishes minimum performance requirements, and describes test methods for measuring the electrical characteristics of control heads and control cable assemblies used with law enforcement mobile transceivers. The standard addresses the control head, its control functions, the control cables used to connect the transceiver to the control head, the connectors on each end of the control cable, and the power cable connecting the transceiver to the vehicular battery. The use of this standard is intended to achieve interchangeability and compatibility among control heads, control cables, and connectors used with law enforcement mobile transceivers, regardless of the manufacturer or model.

**20905.** Uribe, R. M.; McLaughlin, W. L.; Miller, A.; Dunn, T. S.; Williams, E. E. **Possible use of electron spin resonance of polymer films containing leucodyes for dosimetry**, (Proc. 3d Int. Meet. Radiation Processing, Tokyo, Japan, Oct. 26-30, 1980), Paper in *Radiat. Phys. Chem.* 18, No. 5-6, 1011-1016 (Pergamon Press, Oxford, 1981).

Key words: dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosaniline; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical.

When plastic films containing leucocyanides of triphenylmethane dyes are irradiated with large doses of <sup>60</sup>Co gamma rays, free radicals are formed that are sufficiently stable for analysis at room temperature. It is shown that by separating the electron spin resonance spectrum due to free radicals produced in the polymeric host materials from that of the dye precursor, the number of spins associated with a free radical produced in the substituted triphenyl methyl radical can be determined as a means of dosimetry. Instabilities in the free radical populations are evaluated, and methods of preparing plastic films containing triphenylmethane leucocyanides are described. Not only can dosimetry be achieved at higher doses than are normally used with spectrophotometry of this films, but also information about the radiation chemistry of dye formation can be derived.

**20906.** Dobbyn, R. C.; Gorden, R. A., Jr. **Selection and application guide to police body armor**, *NILECJ Standard-0101.01*, 23 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Sept. 1981).

Key words: armor; ballistic protection; ballistic threat; commercial body armor; performance standards; police body armor; protective undergarments.

The guide provides information to assist police in the selection of body armor to provide full time protection throughout a full shift of duty. Data are provided to demonstrate the effectiveness of body armor in protecting police. Specific weapon threats are related to ballistic protection and the classifications of the five threat levels included within the voluntary national performance standard for police body armor, NILECJ-STD-0101.01.

Background information concerning the effort sponsored by the National Institute of Justice to develop an armor suitable for full time use is provided to acquaint the reader with the factors that are important to the performance and wearability of body armor. The use and maintenance of police body armor are discussed. The use of NILECJ-STD-0101.01 as a basis for procurement is described in detail.



20907. Spence, D.; Chupka, W. A.; Stevens, C. M. Mass spectrometric observation of the stable negative molecular ions  $\text{HI}^-$  and  $\text{H}_2\text{I}^-$ , *J. Chem. Phys.* 76, No. 5, 2759-2761 (Mar. 1, 1982).

Key words: mass spectrometry; negative molecular ions; Penning ionization source.

Using a 100" radius double focusing mass spectrometer we have detected the negative molecular ions  $\text{HI}^-$  and  $\text{H}_2\text{I}^-$  produced in a Penning ionization discharge source. The ions are identified by an absolute precision mass measurement, and their flight time through our machine is  $\approx 10^{-4}$  sec, indicating the ions are stable with respect to autodetachment. This observation determines the electron affinity of HI to be positive and  $>0.007$  eV.

20908. Souders, T. M. A dynamic test method for high-resolution A/D converters, *IEEE Trans. Instrum. Meas.* IM-31, No. 1, 3-5 (Mar. 1982).

Key words: analog-to-digital converters; code transition levels; converter testing; dynamic testing; high resolution; settling time; step response.

A dynamic test method is described for A/D converters having up to 16 bits of resolution. The technique exercises the test converter with stepped input changes, simulating the output of an S/H amplifier. Dynamic errors as low as 4 ppm can be measured within 4  $\mu\text{s}$  following a step change as large as 20 V.

20909. Chapman, R. E.; Hall, W. G. Code compliance at lower costs: A mathematical programming approach, *Fire Technol.* 18, No. 1, 77-89 (Feb. 1982).

Key words: applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; renovation.

The identification of cost-effective levels of fire safety in health care facilities is a major concern to hospital administrators, fire safety engineers and public policy makers.

20910. Calvano, N. J. Ballistic resistant protective materials, *NIJ Standard-0108.00*, 7 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Dec. 1981).

Key words: armor; ballistic protection; ballistic resistant materials; bulletproof glass; glazing materials; transparent armor.

This is a standards document; it establishes minimum performance requirements and methods of test for ballistic resistant protective materials. This standard supersedes NILECJ-STD-0103.00, Portable Ballistic Shields, dated May 1974, by expanding the applicability of the standard to all materials used to provide ballistic protection against gunfire, including portable ballistic shields. In addition, this standard establishes threat level classifications that are consistent with other NIJ standards for ballistic protection.

20911. Stahl, F. I. BFIRE-II: A behavior based computer simulation of emergency egress during fires, *Fire Technol.* 18, No. 1, 49-65 (Feb. 1982).

Key words: building codes; building fires; computer-aided design; computer simulation; emergency egress; fire research; human performance; modeling; pedestrian movement; regulatory process; simulation of human behavior.

This paper acquaints the reader with BFIRE, a computer program designed to simulate the emergency egress behavior of building occupants during fires. Use of the program is illustrated, and findings concerning the simulation's validity are presented.

20912. Rehm, R. G.; Bright, D. S. First-order kinetic titrimetry, *Anal. Chem.* 54, 398-401 (Mar. 1982).

Key words: chemical kinetics solution; kinetic titrimetry; ordinary differential equation solution; parabolic cylinder functions; titration.

We solve the equations describing a first-order kinetic titration by reducing them to a single nonlinear ordinary differential equation. When the rate of addition of titrant is constant, the equation depends

on time and only two parameters, which are related to this rate and to the equilibrium constant. The exact analytical solution provides a method for determining the overall character of this chemical kinetics system and provides guidelines for choosing numerical methods to evaluate the solution for all values of the parameters. Direct numerical integration of the equation is convenient for determination of titrand concentrations for some, but not all conditions of experimental interest. For conditions approaching those of ideal titration, i.e., of equilibrium with zero reverse reaction, numerical integration is difficult and we supply simple analytical approximations of the equivalence point concentration.

20913. Calvano, N. J. Ballistic helmets, *NIJ Standard-0106.01*, 9 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Dec. 1981).

Key words: armor; ballistic helmets; ballistic impact; ballistic threat levels; bulletproof helmets; head protectors.

This is a standards document. It establishes performance requirements and methods of test for helmets intended to protect the wearer against gunfire. Requirements for face shields are not included in this standard. The standard is a revision of NILECJ-STD-0106.00, dated September 1975.

This standard redefines the classification system, and establishes threat levels and test rounds that are consistent with companion NIJ standards for ballistic protective equipment and materials.

20914. Taylor, H. C.; Richardson, D. C.; Richardson, J. S.; Wlodawer, A.; Komoriya, A.; Chaiken, I. M. "Active" conformation of an inactive semi-synthetic ribonuclease-S, *J. Mol. Biol.* 149, 313-317 (1981).

Key words: active site; hydrogen bonds; protein structure; ribonuclease-S; semi-synthetic proteins; x-ray methods.

We have studied the integrity of folded structure of a fully active semi-synthetic ribonuclease-S which lacks amino acid residues 16 through 20, and an inactive one with the same residues deleted and 4-fluoro-L-histidine substituted for active site histidine 12. Using "Y" form crystals, we obtained X-ray structural data to a resolution of 2-6 Å and, incorporating phase information calculated from refined ribonuclease-S coordinates, prepared several types of electron density maps. These showed that the overall backbone structure and active site configuration of both analogues do not differ noticeably from those of the native protein. Structural homology extends to the catalytically relevant side-chain at position 12; 4-F-His assumes the same position as does His in active ribonuclease-S. This supports the view that the 4-F-His12 analogue is inactive due to a change in histidine 12 imidazole basicity, rather than to any significant conformational distortion within the active site.

20915. Bowen, R. L. Composite and sealant resins—Past, present, and future, *Pediatr. Dent.* 4, No. 1, 10-15 (1982).

Key words: acid etch; adhesive bonding; composites; dental resins; fillers; pedodontics.

Composite dental filling materials were developed in response to the shortcomings of silicate cements and unfilled resins (based on methyl methacrylate monomer and its polymer). A hybrid monomer, which came to be known as "BIS-GMA" in the dental literature, was synthesized; this molecule resembles an epoxy resin except that the epoxy groups are replaced by methacrylate groups. BIS-GMA formulations can polymerize rapidly under oral conditions, and they have polymerization shrinkage less than that of methyl methacrylate. BIS-GMA resins are used as binders for glass, porcelain, or quartz particles to form relatively durable direct esthetic filling materials. In combination with the acid-etch technique, developed elsewhere, BIS-GMA formulations are used in the repair of fractured incisor teeth. The combination is also useful to bind orthodontic brackets directly to teeth and for surgical procedures in which teeth are not properly placed or aligned for eruption. This resin without filler is also used to prevent decay by the filling of developmental pits and fissures in teeth which would otherwise have a high susceptibility to caries. Improvements in the glass filler for composite resins may lead to greater durability in their clinical uses. Recent developments in adhesive bonding to teeth will also widen the utility of composites.



**20916.** McKinney, J. E. Apparatus for measuring wear of dental restorative materials, *Wear* 76, 337-347 (1982).

Key words: amalgam; apparatus; composite; dental; instrumentation; pin and disc; restorative; wear.

A pin and disc wear apparatus developed for application to dental restorative materials is described. Fully automatic wear generation and data acquisition were conducted on three specimens simultaneously. At arbitrarily selected intervals during wear generation, a series of track depth measurements on the specimen discs was made around the wear track using linear variable-differential transformers. A discussion of probable error sources and estimates of experimental uncertainties are included.

**20917.** Jacox, M. E. Reaction of F atoms with  $C_6H_6$ . Vibrational spectrum of the  $C_6H_5F$  intermediate trapped in solid argon, *J. Phys. Chem.* 86, No. 5, 670-675 (Mar. 4, 1982).

Key words: benzene; F-atom reactions; infrared spectrum; matrix isolation; phenyl; photodecomposition; 1-fluorocyclohexadienyl.

When the products of the reaction between F atoms produced in a microwave discharge and benzene are frozen in a large excess of argon at 14 K, new infrared absorptions appear which can be assigned to the 1-fluorocyclohexadienyl radical. There is no evidence for the stabilization of an intermediate in which the F atom is symmetrically complexed to the  $\pi$  electron ring. Under the conditions of these experiments, there is also no evidence for the occurrence of secondary F-atom reactions. The spectrum observed for  $C_6H_5F$  can be correlated with that reported for  $C_6H_5D$  and, except for the failure to observe the strong C=C stretching absorption, with that of 1,4-cyclohexadiene. The CF-stretching absorption of the addition product has not been identified. Similar correlations aid in the assignment of the infrared spectrum of  $C_6D_5F$ . The threshold for the photodecomposition of  $C_6H_5F$  into  $C_6H_5$  + HF lies between 300 and 280 nm. In solid argon, these products form a hydrogen-bonded complex.

**20918.** Walls, D. F.; Drummond, P. D.; McNeil, K. J. Bistable systems in nonlinear optics, (Proc. Int. Conf. Workshop Optical Bistability, Asheville, NC, June 3-5, 1980), *Optical Bistability*, C. M. Bowden, M. Clifftan, and H. R. Robl, eds., pp. 51-83 (Plenum Publ. Corp., 233 Spring Street, New York, NY 10013, 1981).

Key words: dispersive bistability; fluctuations; nonequilibrium phase transitions; nonlinear optics; optical bistability; second harmonic generation; self pulsing; subharmonic generation.

A review of intracavity nonlinear optical systems exhibiting bistability is presented. We consider a coherently driven Fabry Perot interferometer enclosing an intracavity medium with a non-linear polarizability. As an example of a system with a second-order nonlinear susceptibility  $\chi^{(2)}$  we consider sub/second harmonic generation and for a system with a third-order nonlinear susceptibility  $\chi^{(3)}$  we consider a nonlinear dispersive medium such as Kerr liquid. The conditions under which these systems display bistability are derived. A quantum mechanical analysis enables a calculation of the spectrum and photon statistics of the transmitted light as well as the lifetime of the metastable states.

**20919.** Pallett, D. S.; Tarica, M.; Quindry, T. L.; Jones, F. E. Emergency vehicle sirens, *NIJ Standard-0501.00*, 10 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Dec. 1981).

Key words: emergency vehicle sirens; environmental tests; law enforcement; performance test methods.

This document is a voluntary national standard that establishes minimum performance requirements and describes methods of test that determine the effectiveness of sirens that are intended for use on law enforcement vehicles. The standard classifies sirens on the basis of acoustical performance and addresses other attributes including: design and safety, electrical characteristics, operating life, high and low temperature operation, exposure to dust and moisture, and corrosion resistance.

**20920.** Nesbitt, D. J.; Leone, S. R. Infrared fluorescence studies of intramolecular vibrational relaxation in  $C_1-C_4$  hydrocarbons

following pulsed laser excitation of the first CH stretch overtone, *Chem. Phys. Lett.* 87, No. 2, 123-127 (Mar. 19, 1982).

Key words: hydrocarbons; intramolecular relaxation; laser; vibrational relaxation.

A dramatic reduction in infrared fluorescence quantum yield with increasing molecular size is observed for directly excited first CH stretch overtones in a series of  $C_1-C_4$  hydrocarbons. Ethane and larger molecules ( $\rho_{vib} > 15$  states  $cm^{-1}$ ) appear to undergo rapid intramolecular relaxation within the 1  $\mu s$  detector risetime.

**20921.** Lowney, J. R.; Bennett, H. S. Effect of donor impurities on the conduction and valence bands of silicon, *J. Appl. Phys.* 53, No. 1, 433-438 (Jan. 1982).

Key words: bandgap narrowing; band states; donor impurities; Fermi energy; silicon; Yukawa potential.

The energy shifts of valence and conduction band states in silicon due to the interaction of electrons and holes with ionized donors have been calculated by performing a partial wave analysis. The potential is modeled by the Yukawa form with the screening radius determined self-consistently by the Friedel sum rule. The results show that this effect is an important part of the optically measured band-gap narrowing. The variation of the Fermi energy due to this phenomenon is also calculated.

**20922.** Mayo, S.; Lucatorto, T. B.; Luther, G. G. Laser ablation and resonance ionization spectrometry for trace analysis of solids, *Anal. Chem.* 54, 553-556 (1982).

Key words: laser ablation; laser-produced vaporization; laser-solid interaction; plasma production and heating by laser beam; pulsed-dye laser application; resonance ionization spectroscopy; trace analysis of solids; two-photon absorption spectroscopy.

The first application of resonance ionization spectrometry to trace analysis of solids is demonstrated by using laser ablation to evaporate small amounts of single-crystal silicon and detecting sodium in the evaporated material. Sodium is detected by using two tunable laser probes to induce resonantly enhanced multiphoton ionization. Several samples, both Czochralski and float-zoned silicon, were analyzed. Using certain simplifying assumptions about the laser-evaporated plume, we estimated that the sodium contamination density in the purest sample was of the order of  $10^{11}$  atoms/ $cm^3$ . For further development of this technique for absolute quantitative measurements, the various processes involved in laser evaporation of solids should be more completely understood. Generalization of this technique to other contaminant species in metals, semiconductors, and insulators is subject to laser availability.

**20923.** Lovas, F. J.; Suenram, R. D.; Snyder, L. E.; Hollis, J. M.; Lees, R. M. Detection of the torsionally excited state of methanol in Orion A, *Astrophys. J.* 253, 149-153 (Feb. 1, 1982).

Key words: interstellar, molecules; line identifications; nebulae, Orion Nebula.

We report the detection of torsionally excited methanol ( $CH_3OH$ ,  $v_7=1$ ) in Orion A. Three emission lines have been observed in the region of 93 GHz to 100 GHz. These coincide with laboratory measurements for the  $1_0-2_1$ ,  $E$ ,  $6_1-5_0$ ,  $E$  and blended  $2_1-1_1$ ,  $E$  and  $2_0-1_0$ ,  $E$  transitions of  $CH_3OH$  in its torsionally excited state which lies near 200  $cm^{-1}$  ( $\sim 290$  K) above the ground state. Hence, torsionally excited methanol is a new temperature probe. No emission was detected from the  $2_0-1_0$ ,  $A$  transition which arises from levels near 300  $cm^{-1}$  ( $\sim 430$  K) above the ground state. Several other weak features not attributable to methanol were also observed, and possible identifications are reported.

**20924.** Pine, A. S.; Patterson, C. W. Doppler-limited spectrum and analysis of the  $2\nu_1+\nu_3$  band of  $SF_6$ , *J. Mol. Spectrosc.* 92, 18-32 (1982).

Key words: anharmonicity; combination band; high-resolution; molecular spectroscopy; transition moments; tunable lasers.

The Doppler-limited spectrum of the  $2\nu_1+\nu_3$  band of  $SF_6$  was recorded at 160 and 295 K using a tunable laser difference-frequency spectrometer. The lower temperature eliminates complications from



hot bands and reduces the Doppler width, thereby enhancing the resolution and ground-state intensities. An analysis of the band based on an isolated  $l=1 F_{1u}$  mode yields rotational constants in good agreement with those predicted from the  $\nu_1$  and  $\nu_3$  fundamentals. Small perturbations are observed indicating resonant crossings with nearby vibrations. The  $X_{11}$  anharmonic constant is obtained from the band center and previous measurements of  $\nu_1$ ,  $\nu_3$  and  $\nu_1 + \nu_3$ ; this is the final parameter needed to calculate the entire  $m\nu_1 + n\nu_3$  combination ladder.

**20925.** Kamper, R. A. Current trends in NBS calibration services, *NCSL Newslett.* 22, No. 1, 38-39 (Mar. 1982).

Key words: calibration services; documentation; Measurement Assurance Programs; measurement quality control; metrology management; special tests.

Recently, the management of NBS has given close attention to calibration services and has started several actions to improve quality and responsiveness in the future.

**20926.** Mordfin, L. Introduction to residual stress measurement, *Proc. Symp. Nondestructive Measurement of Wheel/Axle Residual Stress, Cambridge, MA, June 16-17, 1981*, pp. 2.1.1-2.1.19 (U.S. Department of Transportation, Federal Railroad Administration, Cambridge, MA, 1981).

Key words: Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; residual stress; stress measurements; ultrasonics; x-ray diffraction.

The origins and the effects of residual stresses are described, and several of the more prominent methods of measuring residual stresses are reviewed. Both destructive and nondestructive methods are included. The principal emphasis is on the relative capabilities and limitations of the various methods.

**20927.** Powell, C. J.; Erickson, N. E.; Madey, T. E. Results of a joint Auger/ESCA round robin sponsored by ASTM committee E-42 on surface analysis. Part II. Auger results, *J. Electron Spectrosc. Relat. Phenom.* 25, 87-118 (1982).

Key words: Auger-electron spectroscopy; round robin; surface analysis.

We report the results of a round robin involving kinetic-energy (KE) and relative-intensity measurements on high-purity samples of copper and gold by Auger-electron spectroscopy. These results were obtained using 28 different instruments or analyzers manufactured by four companies. We found that the spread in reported KE values ranged from 7 eV at a KE of 60 eV to 32 eV at a KE of  $\sim 2025$  eV. The total spread in reported intensity ratios ranged from a factor of  $\sim 38$  for the  $\sim 60$  eV and  $\sim 920$  eV peaks of Cu to a factor of  $\sim 120$  for the  $\sim 70$  eV and  $\sim 2025$  eV peaks of Au. We have analyzed the observed trends in some detail. The systematic error of kinetic-energy measurements increases with kinetic energy for many instruments. Even though all instruments were adjusted with the use of 2 keV elastically scattered electrons, the spread in the reported positions of the  $\sim 2025$  eV Au peak indicates that the instruments were not adequately calibrated. Examples of erratic response were found in the measurements of relative intensities; it was believed, though not proved, that the more extreme values of intensity ratios were associated with instrumental malfunctions or operator mistakes. As in the similar ESCA round robin (Part I), the spread in reported Auger kinetic energies and relative intensities demonstrates clearly the need for standards (e.g., calibration methods, operating procedures, and data analysis) to ensure that data of known accuracy can be obtained routinely. Until suitable standards are available, interested individuals may find it useful to compare measurements using their own Auger or ESCA instruments with the group results and the trends found in the round-robin results.

**20928.** Kruger, J. Corrosion principles and surface modification, (Proc. Sagamore Army Materials Research Conf. on Surface Modification, Sagamore Hotel, Bolton Landing, Lake George, NY, July 16-20, 1979), Chapter 6 in *Surface Treatments for Improved Performance and Properties*, J. J. Burke and V. Weiss, eds., pp. 93-107 (Plenum Press, New York, 1982).

Key words: breakdown of passivity; corrosion; electrochemistry; passivity; repassivation; surface modification.

The thermodynamic and kinetic principles governing corrosion are described. These are then used to develop thermodynamic and kinetic strategies whereby surface modification techniques can be applied to enhance the corrosion resistance of metals.

**20929.** Birnbaum, G.; Brown, M. S.; Frommhold, L. Lineshapes and dipole moments in collision-induced absorption, *Can. J. Phys.* 59, No. 10, 1544-1554 (1981).

Key words: argon; binary mixtures; collision-induced absorption; potential functions; spectral moments; translational spectrum; wave mechanical lineshapes.

Wave mechanical lineshapes of collision-induced absorption spectra are computed for binary mixtures of argon with helium, neon, and krypton using theoretical dipole moments as input. Comparison with measured spectra shows satisfactory agreement except for the neon-argon mixture, for which either theory or measurement is seen to be in substantial error. Empirical models of the collision-induced dipole moment which reproduce the experimental spectra more closely than the fundamental theory are also given. Best agreement between computed and experimental lineshapes is obtained when potential models which are accurate in the repulsive region are used.

**20930.** Prosen, E. J. Adiabatic solution calorimetry and standards, (Proc. Workshop Techniques for Measurement of Thermodynamic Properties, Albany, OR, Aug. 21-23, 1979), *Bur. Mines Inf. Circ.* 8853, pp. 152-160 (Albany Research Center, Bureau of Mines, Albany, OR, 1981).

Key words: adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane.

The high accuracy platinum-lined adiabatic solution calorimeter of the National Bureau of Standards is described briefly. Its capabilities for working with highly corrosive substances, at temperatures from 278 (5°C) to 368 (95°C), and for reaction times as long as 20 hours are illustrated. Values for the enthalpies of reaction of four different standards or Standard Reference Materials are given.

**20931.** Chuang, T. A diffusive crack-growth model for creep fracture, *J. Am. Ceram. Soc.* 65, No. 2, 93-103 (Feb. 1982).

Key words: crack growth model; creep cavitation; diffusive crack growth; energy release rate; high temperature fracture; J-integral; Si-Al-O-N; singular integral equation.

A grain-boundary creep-crack-growth model is presented based on the assumptions that a crack propagates along the grain boundary by a coupled process of surface and grain-boundary self-diffusion, the adjoining grains on either side of the boundary behave elastically, and steady state conditions prevail. Under the action of the applied stress, atoms on the crack surfaces are driven by surface diffusion toward the crack tip, from where they are deposited nonuniformly by grain-boundary diffusion along the grain interface so that the grain-boundary opens up in a wedge shape ahead of the advancing tip which, in turn, produces a misfit residual stress field. The total grain-boundary normal stresses which are the sum of this misfit stress field and that due to applied stress as well as the boundary opening displacements due to materials deposition are solved from a singular integrodifferential equation to give the following equation relating  $K$  to  $v$ :  $K/K_{min} = 1/2[(v/v_{min})^{1/12} + (v/v_{min})^{-1/12}]$  where  $K$  is the applied mode I crack-tip stress intensity factor,  $K_{min} = 1.69 K_G$  is the minimum  $K$  below which no crack growth is predicted,  $K_G$  being the critical  $K$  based on the Griffith theory;  $v$  is the fixed crack-tip velocity, and  $v_{min}$  is the minimum  $v$  for which  $K = K_{min}$ . In terms of the conventional expression of  $v \propto K^n$ , the present model predicts the values of  $n$  varying from 12 to infinity. A comparison with a set of creep crack-growth data on Si-Al-O-N at 1400°C shows good agreement between theory and experiment. A detailed analysis of the energy balance for the present model is also presented which indicates that  $J$  or  $(1-v^2)K^2/E$  is indeed the correct energy release rate during the crack growth, as is true in the theory of elastic fracture mechanics. However, the major portion of the energy released in the diffusion processes comes from work done by the normal stress in opening up



the grain boundary to accommodate the diffused material rather than from strain energy released by the adjoining grains.

**20932.** Furukawa, G. T. Platinum resistance thermometry in thermodynamic measurements, (Proc. Workshop Techniques for Measurement of Thermodynamic Properties, Albany, OR, Aug. 21-23, 1979), *Bur. Mines Inf. Circ.* 8853, pp. 7-26 (Albany Research Center, Bureau of Mines, Albany, OR, 1981).

Key words: fixed points; International Practical Temperature Scale of 1968; platinum resistance thermometry.

The standard platinum resistance thermometer (SPRT) is the interpolating instrument on the International Practical Temperature Scale of 1968 (IPTS-68) from 13.81 to 903.89 K. The IPTS-68 was designed to be a close approximation to the Kelvin thermodynamic temperature scale within the limits of experimental uncertainty believed at the time of the adoption of the scale. The procedure employed at the National Bureau of Standards in the calibration of SPRT's on the IPTS-68 is described. Except for the extremes of range, the temperature values of SPRT's are reproducible to about  $\pm 1$  mK. Applications of SPRT's and other thermometers in thermodynamic measurements in the range of SPRT's as well as outside the range are discussed.

**20933.** Mangum, B. W. Practical thermometers and temperature scales, (Proc. Workshop Techniques for Measurement of Thermodynamic Properties, Albany, OR, Aug. 21-23, 1979), *Bur. Mines Inf. Circ.* 8853, pp. 27-50 (Albany Research Center, Bureau of Mines, Albany, OR, 1981).

Key words: EPT-76; germanium resistance thermometers; IPTS-68; magnetic thermometers; NQR thermometers; rhodium-iron thermometers; thermistors.

Since thermodynamic temperatures are very difficult to measure, a practical scale of temperatures approximating the thermodynamic temperature at several fixed points, with a prescribed procedure for interpolating between those points with standard instruments, was developed. The latest version of the practical scale is the International Practical Temperature Scale of 1968 (amended edition of 1975) (IPTS-68), the lowest temperature of which is at the triple point of hydrogen. In 1978, a provisional scale (EPT-76) extending from 0.5 to 30 K was promulgated by the International Committee of Weights and Measures in order to correct the lower end of the IPTS-68 and to extend it to lower temperatures. This new scale and its realization are discussed. The application of these scales is through suitably calibrated practical thermometers such as thermistors and other resistance thermometers, electronic and nuclear paramagnetic thermometers, nuclear quadrupole resonance thermometers, and several other less widely used thermometers. A discussion is given of some of the advantages and limitations of some of these practical thermometers, with special emphasis on thermistors.

**20934.** Walls, F. L. Future of quartz resonator thermometry, (Proc. Workshop Techniques for Measurement of Thermodynamic Properties, Albany, OR, Aug. 21-23, 1979), *Bur. Mines Inf. Circ.* 8853, pp. 51-61 (Albany Research Center, Bureau of Mines, Albany, OR, 1981).

Key words: hysteresis; quartz crystal resonators; quartz resonator thermometry.

This paper will attempt to predict the future of precision thermometry based on quartz crystal resonators used as thermal sensors. At present, quartz resonator thermal sensors exhibit considerable hysteresis after temperature cycling and, therefore, are not generally used for precision thermometry. However, we have shown that the sensors can be used to detect temperature fluctuations of approximately 20  $\mu$ K over many seconds. Moreover, major advances in quartz resonators, including new crystallographic cuts, hold promise of producing quartz resonators with greatly reduced hysteresis. These new advances will be discussed in terms of their implication for thermometry from  $\approx 100$  to 400 K. A new technique for utilizing quartz resonators for thermal measurements will be discussed in detail. It is expected that a few of these improved resonators will become available for testing within a few months.

**20935.** Staples, B. R. Evaluation of activity and osmotic coefficients for

electrolyte solutions, basic methodology, (Proc. Workshop Techniques for Measurement of Thermodynamic Properties, Albany, OR, Aug. 21-23, 1979), *Bur. Mines Inf. Circ.* 8853, pp. 286-292 (Albany Research Center, Bureau of Mines, Albany, OR, 1981).

Key words: activity coefficient; correlation; critical evaluation; electrolyte theories; models; osmotic coefficient; polyvalent electrolytes; thermodynamics properties.

A number of models and associated correlating equations used in electrolyte theory and critical evaluations of thermodynamic properties of aqueous solutions are discussed. The methodology and philosophy used in critical evaluation schemes are summarized.

**20936.** Goldberg, R. N. Evaluation of activity and osmotic coefficients for electrolyte solutions: Applications to real systems, (Proc. Workshop Techniques for Measurement of Thermodynamic Properties, Albany, OR, Aug. 21-23, 1979), *Bur. Mines Inf. Circ.* 8853, pp. 293-304 (Albany Research Center, Bureau of Mines, Albany, OR, 1981).

Key words: activity coefficient; critical evaluation; electrolyte; excess Gibbs energy; osmotic coefficient; solutions; thermodynamic properties.

Some of the philosophy that has guided the evaluation efforts in which the author has recently been engaged is presented. Consideration is given to the accuracy and the state of the art with which activity and osmotic coefficients for aqueous electrolyte solutions can be calculated using the following methods of measurement: vapor pressure measurements, direct and relative (isopiestic); electromotive force measurements with and without transference; freezing point depression measurements; vapor pressure osmometry measurements; diffusion measurements; solvent extraction measurements; and ultracentrifuge measurements. The role of the choice of the correlating equation(s) and the difficult problem of the proper merging of the experimental data with the Debye-Hückel limiting law are discussed.

**20937.** Ayres, T. R.; Linsky, J. L. Outer atmospheres of cool stars. X. HR 1099 at quadrature, *Astrophys. J.* 254, No. 1, 168-174 (Mar. 1, 1982).

Key words: stars, binaries; stars, chromospheres; stars, individual; stars, late-type; ultraviolet, spectra.

We report high dispersion, far-ultraviolet (1150–2000 Å) spectra of the active chromosphere, RS CVn binary HR 1099=V711 Tauri (K0 IV+G5 V) obtained with the *International Ultraviolet Explorer*. Observations were taken near the opposite orbital quadratures (maximum radial velocity separation). Emission features produced by high temperature species, such as C II and C IV, are very bright, exhibit structure, change significantly in the one week interval separating the two exposures, and generally follow the radial velocity motion of the K subgiant primary. The less massive G dwarf secondary appears only weakly in the composite spectrum, if at all. We conclude, in agreement with previous studies, that chromospheric and transition region emission in RS CVn binaries is genuinely a stellar, rather than a system, phenomenon. The association of the major emission source with the more rapidly rotating and somewhat cooler primary lends support to the rotation-activity connection thought to be at least partially responsible for establishing the magnetic behavior of convective stars. We interpret the structure apparent in some of the emission line shapes as a patchy brightness distribution on and above the K star surface that is spread out in velocity by the rapid rotation. We argue further, from the general appearance of the emission line shapes, that the chromosphere is confined to the stellar surface, while the higher temperature material resides in a more extended volume of space around the K star. A similar argument provides support for the notion that the He II 1640 Å Balmer  $\alpha$  emission is formed in the chromosphere by a photoionization-recombination mechanism, rather than at higher temperatures by direct collisional excitation.

**20938.** Hummer, D. G.; Rybicki, G. B. A unified treatment of escape probabilities in static and moving media. I. Plane geometry, *Astrophys. J.* 254, No. 2, 767-779 (Mar. 15, 1982).

Key words: line formation; line profiles; radiative transfer.



An expression giving the escape probability for photons in a spectral line formed in a planar atmosphere with an arbitrary monotonic velocity law is derived and evaluated. For a small velocity gradient, the usual static result is recovered; for large velocity gradients the Sobolev result is obtained, but *only at optical depths sufficiently large* that the "static" part of the escape probability is negligible. Extensive numerical results for the escape-probability function for a constant velocity gradient are given for Doppler, Voigt ( $a=10^{-3}$ ,  $10^{-2}$ ) and Lorentz profiles. The use of these results for flows with non-constant gradients is discussed.

**20939.** Cauvin, M.; Gillet, V.; Soulmagnon, F.; Danos, M. Mass formula based on SU(4), *Nucl. Phys. A361*, 192-212 (1981).

Key words: atomic masses; binding energies; mass formula; nuclear shell effects; quartetting; supermultiplets.

The quality of the fit of experimental masses by a mass formula based on the two-body Casimir operator of SU(4) is tested and found to be at least as good as that of the Weizsäcker mass formulae, in spite of the fact that this formula is inherently less flexible. The physical basis for, and some ramifications of, this formula are discussed. A simple form for the shell corrections is then added in the formulae, leading to improved fits without modification of the above conclusions.

**20940.** Fanney, A. H.; Thomas, W. C. Three experimental techniques to duplicate the net thermal output of an irradiated collector array, *Proc. 4th Annu. Conf. ASME Solar Energy Division, Albuquerque, NM, Apr. 26-29, 1982*, pp. 511-518 (The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017, Apr. 1982).

Key words: ASHRAE 95; collectors; solar domestic hot water; solar simulator; standard; test method.

A relevant and repeatable test method is required to provide a means for rating solar domestic hot water systems. The test method should be independent of the geographical location of the laboratory and the prevailing outdoor environment. Three experimental techniques which reproduce the net thermal output of a normally irradiated solar collector without the use of a solar simulator are investigated. These techniques include the use of an in-line electrical heat source only, use of a nonirradiated collector array in series with a heat source, and the use of electrical strip heaters attached to the back of nonirradiated absorber plates.

Two single-tank direct solar domestic hot water systems have been fabricated at the National Bureau of Standards to validate each experimental technique. The solar collector array of one system is subjected to outdoor meteorological conditions. The second system, used to validate the experimental techniques, is located entirely indoors. Daily tests of the solar domestic hot water system with the irradiated collector array were subsequently repeated for the laboratory system using the three experimental techniques. Based on results from several nearly clear and intermittently cloudy days, all three simulation techniques reproduce the net thermal output of the normally irradiated collector array within four percent. Pump controller operation can be closely reproduced using two of the techniques. Advantages and limitations of each method are discussed.

**20941.** Wipf, H.; Magerl, A.; Shapiro, S. M.; Satija, S. K.; Thomlinson, W. Neutron-spectroscopic evidence for hydrogen tunneling states in niobium, *Phys. Rev. Lett.* **46**, No. 14, 947-950 (Apr. 6, 1981).

Key words: hydrogen in metals; impurities; inelastic structure factor; neutron spectroscopy; niobium; tunneling.

Inelastic neutron scattering measurements demonstrating H tunneling states for O-H pairs in NbO<sub>0.013</sub>H<sub>0.016</sub> are presented. The tunneling matrix element found is  $0.19 \pm 0.04$  meV.

**20942.** Rendell, R. W.; Girvin, S. M. The quantum Hall effect: Role of inversion layer geometry, *Surf. Sci.* **113**, 39-40 (1982).

Key words: density of states; Hall effect; inversion layer; Landau level; MOSFET.

The quantum Hall effect has attracted much interest because of its potential for providing a quantum standard of resistance and an improved value of the fine structure constant. As a step toward understanding the experimental and fundamental limitations of the effect, we present a calculation of end effect errors for MOSFET devices within a simple model of an inversion layer.

**20943.** Zekowitz, M. V.; Lyle, J. Implementation of program specifications, (Proc. 4th Computer Soc. Int. Software and Applications Conf., Chicago, IL, Oct. 29-31, 1980), *COMP 80*, pp. 194-200 (IEEE Computer Society, P.O. Box 639, Silver Spring, MD 20910, Oct. 1980).

Key words: assertions; data abstractions; implementation; PL/I; specifications; validation.

A PL/I system, called PLACES, is described which has been extended to provide data abstraction and program validation mechanisms. These two features create a practical model for program specifications. The designs of these features as well as their proposed usage is explained.

**20944.** Hardman, K.; Rhyne, J. J.; Malik, S.; Wallace, W. E. Site magnetization of cubic and hexagonal HoMn<sub>2</sub>, *J. Appl. Phys.* **53**, No. 3, 1944-1946 (Mar. 1982).

Key words: crystal fields; ferromagnetism; manganese compounds; neutron diffraction; profile refinement; rare earths.

Magnetic neutron diffraction profile refinement methods have been used to determine the Ho and Mn site magnetizations in both the cubic C15 and hexagonal C14 Laves phases of HoMn<sub>2</sub>. The results are correlated with measurements of the temperature dependence of the bulk magnetization, which gave a  $T_c$  for both phases of 26 K and overall saturation magnetizations of  $6.4 \mu_B$  for the cubic phase and  $6.7 \mu_B$  for the hexagonal phase, as extrapolated from field data up to 20 kOe at 4 K. Individual sublattice moments obtained by profile refinement were, for the cubic phase, a Ho moment of  $8.1 \mu_B$ , reduced from the free ion value of  $10 \mu_B$  by crystal field effects, and a Mn moment of  $0.84 \mu_B$  coupled antiferromagnetically, giving an overall magnetization in agreement with the magnetometer results. In the hexagonal phase, the Ho moment was  $9.4 \mu_B$  and the two Mn moments were  $-0.64 \mu_B$  and  $-1.03 \mu_B$ . The overall magnetization of  $7.5 \mu_B$  was higher than that found from the magnetization studies, which were affected by the large uniaxial anisotropy on the Ho site.

**20945.** Rhyne, J. J.; Fish, G. E.; Lynn, J. W. Spin waves in amorphous Fe<sub>1-x</sub>B<sub>x</sub> alloys, *J. Appl. Phys.* **53**, No. 3, 2316-2318 (Mar. 1982).

Key words: amorphous materials; ferromagnetism; magnetization; neutron diffraction; spin waves; transition metals.

The temperature dependence of spin excitations has been studied in amorphous Fe<sub>1-x</sub>B<sub>x</sub> ( $x=0.18$  and  $0.14$ ) by inelastic neutron scattering. The spin-wave stiffness constant  $D$  was determined directly from the magnon dispersion curves ( $E=Dq^2$ ) over the temperature range from below room temperature ( $T/T_c=0.48$  and  $0.36$ , respectively, for  $x=0.18$  and  $0.14$  alloys) up to 548 K ( $T/T_c=0.75$  and  $0.99$ ), which is just below the crystallization temperature. For both alloys the temperature dependence of  $D$  was found to be proportional to  $(T/T_c)^{3/2}$  up to  $(T/T_c)$  greater than 0.8. The extrapolated values of  $D$  at  $T=0$  were  $D=167$  and  $138$  meV Å<sup>2</sup>, respectively, and were nearly twice as large as those determined from the  $T^{3/2}$  coefficient found from magnetization studies. These anomalies may be related to the Invar characteristics of the thermal expansion in these alloys. Limited data were also obtained for an alloy Fe<sub>76</sub>B<sub>24</sub>, which exhibits a higher  $D(>174$  meV Å<sup>2</sup>).

**20946.** McCarty, R. D. LNG densities for custody transfer, *Proc. 57th Int. School Hydrocarbon Measurement, Norman, OK, Apr. 13-15, 1982*, pp. 417-419 (University of Oklahoma, Norman, OK, 1982).

Key words: computational methods; computer programs; custody transfer; density measurement; density reference standard; liquefied natural gas.

Work has been carried out over the past nine years at the National Bureau of Standards to provide alternate methods for the accurate determination of the density of liquefied natural gas (LNG) that would serve as a basis for equitable custody transfer.



A magnetic suspension densimeter was used to obtain density data for LNG components and their mixtures with a total uncertainty in density of less than 0.1%. These data were used to optimize and test mathematical models for LNG density calculations.

Four mathematical models for the calculation of LNG densities have been optimized, tested, and compared. These models are an extended corresponding states model, a cell model, a hard sphere model, and an empirical model due to Klosek and McKinley.

A density reference system (DRS) was constructed to determine the uncertainty of measurements made by several different types of densimeters proposed for use in the commercial trade of LNG. Several commercial densimeters have been tested and a transfer standard program implemented as a means of producing a calibration service for commercially built densimeters. The total uncertainty of the DRS is estimated to be  $\pm 0.076\%$ .

A portable reference densimeter (PRD) has been developed specifically for calibrating LNG densimeters "in place." The measurements of density using the two systems, DRS and PRD, are statistically indistinguishable.

**20947.** Eisenhart, C. Contribution to panel discussion on training statisticians for employment in industry and government, *Proc. Conf. Teaching of Statistics and Statistical Consulting*, Ohio State University, J. S. Rustagi and D. A. Wolfe, eds., pp. 257-281 (Academic Press Inc., 111 Fifth Avenue, New York, NY 10003, 1982).

Key words: accuracies, comparison of; government careers; in-service training; physics classroom experiments; statistical consulting course; statistics; training.

Comments on, or motivated by, "Consulting and Research in the [Australian] CSIRO Division of Mathematics and Statistics," by Joseph Gani (DMS, CSIRO), "Statisticians' Responsibilities Vis-a-Vis the Computer," by David Hogben (NBS), and "Preparing Statisticians for Government Careers," by Lincoln Moses (U.S. Department of Energy and Stanford University). NBS and CSIRO programs in mathematics and statistics compared and contrasted with respect to size, scope, operations, recruitment and in-service training. Discussion of inadequacy of mean square error, and some alternatives thereto, as characterizations of the accuracy of a measurement process, as background for procedure Hogben outlined for comparing the "closeness" with which alternative statistical estimators determine the value of an unknown parameter. Review of the experience and practices of the NBS Statistical Engineering Laboratory (now "Division") with respect to recruitment and in-service training of statisticians. Comments on the shortcomings of university training of statisticians in the U.S.A. for careers in the physical sciences, and mention of current developments in some biostatistics departments and state universities that show promise of overcoming these shortcomings.

**20948.** Rush, J. J.; Magerl, A.; Rowe, J. M.; Harris, J. M.; Provo, J. L. Tritium vibrations in niobium by neutron spectroscopy, *Phys. Rev. B* **24**, No. 8, 4903-4905 (Oct. 15, 1981).

Key words: defect; isotope; metal hydride; neutron scattering; niobium hydride; tritide; vibration spectra.

We report here the first measurement of tritium vibrations in a metal. Neutron spectra for tritium in niobium are compared with results for niobium deuteride and hydride in the same ( $\beta$ ) crystal phase to reveal deviations from a  $\sqrt{M}$  dependence, reflecting the anharmonicity of the potential. Vibration peaks are also observed for dilute H and O impurities in the niobium sample.

**20949.** Magerl, A.; Zabel, H. Phonons in the graphite-potassium intercalation compound  $C_{36}K$ , *Phys. Rev. Lett.* **46**, No. 6, 444-446 (Feb. 9, 1981).

Key words:  $C_{36}K$ ; inelastic neutron scattering; intercalated systems; lattice dynamics; phonons; two-dimensional systems.

An inelastic-neutron-scattering study of the [001] L phonons in  $C_{36}K$  shows, for the first time, zone-folding effects along with frequency gaps between acoustic and optic modes. Phonon dispersion and structure factors can be modeled by a linear chain with two different masses and two force constants:  $\phi_1 = 3450$  dyn/cm for the coupling of graphite and potassium planes, and  $\phi_2 = 2850$  dyn/cm for the coupling between two adjacent graphite planes.

**20950.** Meot-Ner (Mautner), M. Carbon-hydrogen bond dissociation energies in alkylbenzenes. Proton affinities of the radicals and the absolute proton affinity scale, *J. Am. Chem. Soc.* **104**, No. 1, 5-10 (1982).

Key words: aromatic hydrocarbons; bond energies; ion-molecule reactions; proton affinities; radicals.

Rate constants ( $k$ ) were measured for proton-transfer reactions from alkylbenzene ions  $RH^+$  to a series of reference bases B, i.e.,  $RH^+ + B \rightarrow BH^+ + R\cdot$ . For exothermic reactions ( $\Delta H < -1$ )  $k$  is large, but as weaker bases are used and the reaction becomes thermoneutral the collision efficiency decreases sharply. The variation of  $k$  with  $\Delta H$  determines the proton affinity (PA) of the radical  $R\cdot$  relative to a set of reference bases to within  $\pm 0.5$  kcal mol $^{-1}$ . For example, the reaction  $C_6H_5CH_3^+ + B \rightarrow BH^+ + C_6H_5CH_2\cdot$  is fast (reaction efficiency =  $k/k_{col} > 0.5$ ) when  $B = MeO-t-Bu$  or stronger bases, but  $k/k_{col}$  is significantly smaller when B is  $n-Pr_2O$  or weaker bases. From the falloff curve of reaction efficiency vs. PA(B), we find  $PA(n-Pr_2O) = PA(C_6H_5CH_2\cdot) + 0.8$  kcal mol $^{-1} = 200.0$  kcal mol $^{-1}$ . Since  $PA(C_6H_5CH_2\cdot)$  is obtained from known thermochemical data, this relation defines the absolute PA of  $n-Pr_2O$ . Through a ladder of known PA, we then obtain  $PA(i-C_4H_9) = 186.8$  kcal mol $^{-1}$ ; we also obtain the absolute PAs of other oxygen bases. Falloff curves of reaction efficiencies of  $3-FC_6H_4CH_3^+$ ,  $C_6H_5C_2H_5^+$ ,  $C_6H_5-n-C_3H_7^+$ , and  $C_6H_5-i-C_3H_7^+$  with these reference bases give then the following PAs of R- and R-H bond dissociation energies ( $D^\circ$ ) (all in kcal mol $^{-1}$ ) as R-:  $PA(R\cdot)$ ,  $D^\circ(R-H)$ :  $3-FC_6H_4CH_2\cdot$ , 197.2, 89.4;  $C_6H_5CHCH_3$ , 197.9, 86.2;  $C_6H_5CHC_2H_5$ , 199.1, 86.1;  $C_6H_5(CH_3)_2$ , 199.6, 86.1. In a similar manner, rate constants for  $H^+$  transfer from  $C_6H_5NH_2^+$  to reference pyridines and amines yield  $PA(C_6H_5NH_2) = 221.5$  and  $D^\circ(C_6H_5NH-H) = 85.1$  kcal mol $^{-1}$  (1 kcal mol $^{-1} = 4.18$  kJ mol $^{-1}$ ).

**20951.** Kovacs, W. D.; Salomone, L. A. SPT hammer energy measurement, *Am. Soc. Civ. Eng. J. Geotech. Eng. Div.* **108**, No. GT4, 599-620 (Apr. 1982).

Key words: boring; drilling; energy; field tests; foundation design; hammer; in-situ tests; Standard Penetration Test.

A field measurement system and procedure which measures the energy delivered by a drill rig system was developed and successfully used to study the factors which affect delivered energy. Results are presented which indicate that the energy delivered by certain drill rig systems varies widely in engineering practice. The energy delivered to the drill stem varied with the number of turns of rope around the cathead, the fall height, drill rig type hammer type, and operator characteristics. The type of hammer had a strong influence on the energy transfer mechanism between the anvil and the drill stem. It appears that the safety (sleeve enclosed) hammer is more efficient in transmitting the available kinetic energy through the anvil to the drill stem than the donut hammer.

**20952.** Norcross, D. W.; Padial, N. T. The multipole-extracted adiabatic-nuclei approximation for electron-molecule collisions, *Phys. Rev. A* **25**, No. 1, 226-238 (Jan. 1982).

Key words: electron-molecule collisions; MEAN approximation; polar molecules.

An extension of the adiabatic-nuclei approximation appropriate for electron collisions with polar molecules is discussed. The method will find most useful application, but is not restricted, to molecules with large permanent dipole moments. Treatment of molecules with small or negligible dipole moments but significant quadrupole moments and/or dipole polarizabilities is also within its purview. The essence of the method consists of extracting the effects of the long-range interactions from the usual adiabatic-nuclei expressions, and reintroducing them in the laboratory frame in a self-consistent manner. The first Born approximation is the simplest, but not the only possible, vehicle for this approach. The method is closely related to the angular frame-transformation method. Illustrative applications are presented.

**20953.** Fujimoto, T.; Phelps, A. V. Transport of resonance excitation in Na vapor excited by white light, *Phys. Rev. A* **25**, No. 1, 322-332 (Jan. 1982).

Key words: backscattering; experiment; forward scattering;



quenching; resonance; sodium; transport.

Experimental line profiles and integrated intensities for backscattered and forward-scattered resonance radiation using white-light excitation are compared with theory for Na densities between  $10^{19}$  and  $10^{22}$  atoms/m<sup>3</sup>. Absorption measurements are used to verify linewidth and line-wing asymmetry parameters and Na-vapor densities. The scattered spectral intensities are normalized to the incident flux using calibrated diffusers. Measurements of scattered intensities were also made as N<sub>2</sub> was added to the Na. The line profiles and integrated intensities were calculated using a model which assumes complete redistribution of the radiation scattered by an atom and takes into account both radiative and nonradiative transport of the resonance excitation. The theory includes the effects of quenching by Na<sub>2</sub> and by admixed N<sub>2</sub>. With the white-light excitation used in these experiments the radiative transport is found to dominate the nonradiative transport except at wavelengths very near line center. The agreement between experimental and theoretical line profiles is good at high sodium densities ( $\sim 5 \times 10^{21}$  atoms/m<sup>3</sup>) where instrumental resolution is not a serious limitation. The agreement between experimental and theoretical integrated intensities is within experimental error for Na densities of  $(1-10) \times 10^{19}$  and  $(2-5) \times 10^{21}$  atoms/m<sup>3</sup>. At the intermediate densities the approximately 20% discrepancy may be caused by the incomplete redistribution of radiation in the scattering process.

**20954.** Keiser, G. M.; Faller, J. E. Eötvös experiment with a fluid fiber, *Proc. Second Marcel Grossmann Meet. General Relativity, Miramare-Trieste, Italy, July 5-11, 1979*, R. Ruffini, ed., pp. 969-976 (North-Holland Publ. Co., Amsterdam, 1982).

Key words: Eötvös experiment; fibers; general relativity; gravitation; null experiments; relativity.

Recent work aimed at an improved Eötvös experiment is described. Copper and tungsten test masses are contained in a cylindrical float supported by the buoyancy of water which is held at its maximum density point. Electrostatic forces are used to keep the float centered and to provide the torsion constant. Sources of noise associated with convection currents, magnetic fields, seismic noise, changing gradients in the gravitational field, long term drifts in the position detector, and Brownian motion are described, and recent experimental results are presented.

**20955.** Parks, E. J.; Brinckman, F. E.; Mullin, C. E.; Andersen, D. M.; Castelli, V. J. Characterization by tin-specific size exclusion chromatography of the free radical copolymerization of tributyltin methacrylate and methyl methacrylate, *J. Appl. Polym. Sci.* **26**, 2967-2974 (1981).

Key words: copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight.

Copolymers of tributyltin methacrylate (TBTM) and methyl methacrylate (MMA) comprise an important class of biocidal slow-release organometallic polymers (OMPs). Little is known of the kinetics and mechanism of copolymerization. TBTM and MMA were copolymerized in the presence of a free radical initiator (benzoyl peroxide) at 80.1°C. Aliquots, taken at preselected intervals from 0 to 1440 min, were fractionated by size exclusion chromatography (SEC) coupled with ultraviolet (UV) and tin-specific graphite furnace atomic absorption (GFAA) detectors. A UV absorbance observed at 254 nm was associated with low-molecular-weight species, decreasing in concentration continuously with time of reaction. Tin-specific GFAA indicated a decrease in low-molecular-weight species (ca. 350 daltons) with concurrent increases in high-molecular-weight species (ca. 40,000 daltons). The fraction of high molecular-weight increased as a linear function of the logarithm of the time of reaction. SEC-UV-GFAA thus provides a tool of major importance for characterizing the time dependence and continuity of the process by which monomers of TBTM are converted to a useful bioactive slow-release coating material.

**20956.** Buehler, M. G.; Perloff, D. S. Microelectronic test chips and associated parametric testers: Present and future, *Semicond. Silicon* **1981**, 81-5, 859-867 (The Electrochemical Society, Inc., 10 South

Main Street, Pennington, NJ 08534).

Key words: integrated circuits; microelectronic test chips; parametric testers; test methods.

Microelectronic test chips for the characterization of materials, process and device parameters are becoming increasingly important tools for the design and production of integrated circuits. Because test chips are implemented using a variety of design criteria and testing approaches, substantial differences may exist in the usefulness of the information they provide. This paper summarizes the present practices in test chip usage and describes the parametric testers now available for test chip characterization. Emphasis is given to the technological changes which will contribute to the more effective use of test chips in the future, including: improved parametric testers, advanced test structures, comprehensive statistical analysis and data presentation techniques, and standards for test structures, test methods, and test languages.

**20957.** Berger, H. An overview: New ideas in nondestructive evaluation, *Rubber Chem. Technol.* **54**, No. 5, 996-1002 (1981).

Key words: acoustic emission; eddy currents; liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; radiography; tire inspection; ultrasonics; visual-optical.

Nondestructive evaluation (NDE) normally brings to mind six major methods in use in industrial quality control, visual/optical, x-ray, ultrasonic, penetrant, magnetic and eddy current techniques. While it is true that most NDE involves these basic methods, it is also true that major changes are taking place in terms of modifications of these standard methods and in terms of new inspection approaches. The discussion includes descriptions of modifications such as ultrasonic imaging, x-ray tomography, pulsed eddy current techniques and signal processing. In addition, novel NDE approaches that appear to offer advantages of tire inspection are discussed; these include acoustic emission, pulsed eddy current, microwaves and vibrothermography.

**20958.** Martinez, R. I.; Herron, J. T. Cyclobutane production via the O<sub>3</sub>-thiolane reaction, *Int. J. Chem. Kinet.* **14**, 439-445 (1982).

Key words: concerted reaction; cyclobutane; ozonation; thiolane.

Cyclobutane (c-C<sub>4</sub>H<sub>8</sub>) was found to be a product of the reaction of ozone with thiolane. It is argued that the cyclobutane is formed in a concerted process: CH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>SO<sup>+</sup> → c-C<sub>4</sub>H<sub>8</sub> + SO, rather than via the biradical mechanism: CH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>SO<sup>+</sup> → CH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>SO → CH<sub>2</sub>(CH<sub>2</sub>)<sub>2</sub>CH CH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>SO<sup>+</sup> is formed in the initial O<sub>3</sub>-thiolane reaction: O<sub>3</sub> + CH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>S → O<sub>2</sub> + CH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>SO<sup>+</sup>.

**20959.** Hanley, H. J. M.; Evans, D. J. A thermodynamics for a system under shear, *J. Chem. Phys.* **76**, No. 6, 3225-3232 (Mar. 15, 1982).

Key words: computer simulation; Couette flow; Lennard-Jones fluid; nonequilibrium molecular dynamics; nonlinear phenomena; phase changes; stability criteria; thermodynamics of the steady state.

A thermodynamics is introduced for fluids subjected to a constant shear. The theory is based primarily on the results of computer simulations using the technique of homogeneous shear nonequilibrium molecular dynamics applied to a system of 108 Lennard-Jones particles. It is supported qualitatively by the results of several authors for other systems. The shear rate  $\gamma$  enters explicitly into the description of the fluid: the equation of state is  $p = p(V, T, \gamma)$  and thermodynamic equation is  $dE = TdS - pdV + \zeta d\gamma$ , where  $\zeta$  is a state function. Using the relations found previously to be valid for a wide range of  $\gamma$ :  $p = p_0 + p_1\gamma^{3/2}$  and  $E = E_0 + E_1\gamma^{3/2}$ , the thermodynamics can be checked numerically for consistency and several consequences, such as stability criteria, can be verified. The criteria indicate that phase changes are influenced by the shear rate when the system is subjected to the shear.

**20960.** Penn, D. R.; Girvin, S. M.; Mahan, G. D. Dispersion relation approach to the x-ray edge problem, *Phys. Rev. B* **24**, No. 12, 6971-6983 (Dec. 15, 1981).

Key words: dispersion relation; perturbation theory; singularity; x-ray edge.



We present a dispersion relation formulation of the open-line amplitude for the x-ray edge problem within the contact potential model. Using both multiple-scattering and determinant techniques, we find that to a very good approximation the many-body effects can be described within a single-particle transition-rate expression using a renormalized matrix element. This renormalized matrix element may be expressed exactly in terms of a frequency integral over the scattering phase shift for the core-hole potential. There are small corrections to the transition rate due to multiple particle-hole-pair final states, and a systematic series expansion for these is presented. This series is summed at threshold to yield an exact expression for the critical amplitude multiplying the power-law singularity. Our analytic results given an exact description at threshold and are shown to be quite accurate away from threshold. Comparison with the asymptotic expression of Nosières and De Dominicis is made.

20961. Richtmyer, T. E.; May, W. B.; Hunt, C. M.; Hill, J. E. Lessons from an energy-efficient test-bed, *Build. Res. Pract.*, pp. 344-359 (Nov./Dec. 1980).

Key words: air-cooling; air leakage; energy; heat-recovery; insulation; measurement; office-building; radiant; solar; space-heating.

The Norris Cotton office building in New Hampshire, USA, is a bold design experiment to achieve year-round comfort conditions with full energy-efficiency. This interim report by staff of the US National Bureau of Standards shows how the design goal has now been virtually achieved. But the building's deliberately complex HVAC system has created control problems, with under-performance of some sub-systems. Moreover, the benefits of sophisticated building details were at first nullified by inadvertent thermal bridges.

20962. Yates, J. T., Jr.; Williams, E. D.; Weinberg, W. H. Reply to comments on "Does Chemisorbed Carbon Monoxide Dissociate on Rhodium?" by D. G. Castner, L. H. Dubois, B. A. Sexton and G. A. Somorjai, *Surf. Sci.* 115, L93-L95 (1982).

Key words: carbon; carbon monoxide; chemisorption; dissociation; rhodium.

20963. Robinson, E. L.; Barker, E. S.; Cochran, A. L.; Cochran, W. D.; Nather, R. E. MV Lyrae: Spectrophotometric properties of minimum light; or on MV Lyrae off, *Astrophys. J.* 251, No. 2, 611-619 (Dec. 15, 1981).

Key words: stars, binaries; stars, dwarf novae; stars, individual.

The nova-like variable MV Lyr is normally at maximum light near  $B \sim 12.5$ , but it occasionally fades to minimum light near  $B \sim 17.3$ . We have obtained photometric and spectrophotometric observations of MV Lyr at maximum light in 1969 and at minimum light in 1980. We show that minimum light is caused by a total cessation of mass transfer from the late-type star to the white dwarf in the system. The distribution of orbital periods of the cataclysmic variables has a gap at orbital periods between 2 hr and 3 hr, and MV Lyr is at the long-period edge of the gap. We argue that the cataclysmic variables do evolve through the gap, but that they cease mass transfer while in the gap, becoming very difficult to detect. MV Lyr is an example of a cataclysmic variable about to enter the gap.

20964. Cooper, J. A.; Currie, L. A.; Klouda, G. A. Assessment of contemporary carbon combustion source contributions to urban air particulate levels using carbon-14 measurements, *Environ. Sci. Technol.* 15, No. 9, 1045-1050 (Sept. 1981).

Key words: air pollution; biogenic/fossil carbon impact; field and slash burning; Portland aerosol characterization study; radiocarbon; residential wood burning; urban particulates; vegetative burning.

Measurement of carbon-14 activities with new low-level counting methods has been demonstrated to be an effective tool for assessing the contribution of contemporary carbon combustion sources to the mass collected with typical high-volume air samplers. This study represents the first time that radiocarbon measurements have been applied to fine particles ( $< 2 \mu\text{m}$ ) and used to assess the contribution of specific sources to urban air quality. Radiocarbon analysis of fine particles minimized interferences from large particles such as pollen, spores, wood fiber, etc., and improved the method's ability to assess

the impact of burning vegetative material such as field and slash burning and space heating with wood. Slash burning contributed between 39% and 70% of the fine particulate mass while field burning contributed 50% of the total suspended particulates (TSPs) on high-impact days in the Portland and Eugene, OR, airsheds. Radiocarbon analysis of filters selected for high impact from residential wood combustion shows that this source is a substantial contributor to fine particulate mass during winter months in Portland, OR.

20965. Zielinski, W. L., Jr.; Scanlan, R. A.; Miller, M. M. Feasibility study of high-temperature liquid crystals in wall-coated open-tubular columns, *J. Chromatogr.* 209, 87-90 (1981).

Key words: gas-liquid chromatography; liquid crystals; polycyclic aromatic hydrocarbons; wall-coated open-tubular columns.

High-temperature liquid crystals (mesophase transitions  $> 150^\circ\text{C}$ ) were used as wall coating substrates in wall-coated open-tubular gas chromatographic columns. N,N'-Bis[*p*-n-butoxybenzylidene]- $\alpha,\alpha'$ -bi-*p*-toluidine (BBBT) liquid crystal was selected for this study due to its ready solubility in chloroform for preparation of coating solutions, and its desirable temperature transitions. The separation characteristics of the wall-coated BBBT wide-bore open tubular columns for 3-, 4-, and 5-ring polycyclic aromatic hydrocarbons are consistent with earlier findings for these isomers on packed gas chromatographic columns.

20966. Eisenhauer, C. M.; Schwartz, R. B.; Johnson, T. Measurement of neutrons reflected from the surfaces of a calibration room, *Health Phys.* 42, No. 4, 489-495 (Apr. 1982).

Key words: background; calibration; californium neutrons; personnel monitoring; reflected neutrons; scattered neutrons.

Measurements of the variation of the response of 9-in. spherical rem-meters and 3-in. Bonner spheres with distance from a Cf fission neutron source are presented. Measurements in two different calibration rooms show that the response of an instrument to neutrons reflected from the walls of a room is constant over the central volume of the room. Approximate expressions are given for understanding the response to reflected neutrons in terms of the energy of the neutron source, the type of detector, and the size of the calibration room.

20967. Serbyn, M. R. Absolute measurement of angular vibration, *Proc. Eleventh Transducer Workshop, Seattle, WA, June 2-4, 1981*, L. Bates and K. D. Cox, eds., pp. 260-270 (Secretariat, Range Commanders Council, White Sands Missile Range, NM 88002, May 1982).

Key words: absolute measurement; accelerometer calibration; angular vibration; interferometer; reciprocity calibration; torsional vibration.

With new developments in instrumentation for angular-vibration measurements, the demand for calibration services is expected to grow. This paper investigates the feasibility of measuring the magnitude of vibratory displacement absolutely. The conclusion of a preliminary study is that both reciprocity and interferometry offer viable procedures for this type of measurement. In general, a reciprocity calibration is better suited to angular displacements of low frequency and large amplitude, whereas an interferometric calibration has no practical frequency constraints, but requires that the amplitude of vibration be limited. This is an interim report on work that will be continued.

20968. Luther, G. G.; Towler, W. R. Redetermination of the Newtonian gravitational constant  $G$ , *Phys. Rev. Lett.* 48, No. 3, 121-123 (Jan. 18, 1982).

Key words: gravitational constant; Newtonian gravitational constant.

The universal Newtonian gravitational constant is being redetermined at the National Bureau of Standards with use of the method of Boyes in which the period of a torsion pendulum is altered by the presence of two 10.5-kg tungsten balls. The difference in the squares of the frequencies with and without the balls is proportional to  $G$ . The resulting value of  $G$  is  $(6.6726 \pm 0.0005) \times 10^{-11} \text{ m}^3 \cdot \text{sec}^{-2} \cdot \text{kg}^{-1}$ .

20969. Mink, A.; Silio, C. B., Jr. An approximate queueing network model of a shared device among independent computing systems, *Proc. Fall COMPCON 81: Productivity an Urgent Priority, Capitol*



Hilton Hotel, Washington, DC, Sept. 15-17, 1981, pp. 156-166 (IEEE Computer Society, P.O. Box 80452, Worldway Portal Center, Los Angeles, CA 90080).

Key words: approximate queueing model; computer architecture; performance modeling; queueing model; queueing networks.

An approximate queueing network model of a special class of computer architecture is presented. The configuration of this class is that of several independent computing systems sharing a single processing resource. This approximate model represents each device in the network as a single server queue. A relationship to approximate the job arrival rate at each device is established as a function of the network parameters and the corresponding number of jobs in a related closed queueing network model. This model is both memory space and computation time efficient; whereas, exact models require exponential growth in computation time as the number of independent systems increases. The results of this approximate model are compared to those of the exact model.

20970. Hess, S. Non-Newtonian viscosity and normal pressure differences of simple liquids, *Phys. Rev. A* 25, No. 1, 614-616 (Jan. 1982).

Key words: Kirkwood-Smoluchowski equation; liquids; nonequilibrium phenomena; nonNewtonian viscosity; statistical mechanics.

An equation governing the friction pressure tensor is derived from the Kirkwood-Smoluchowski equation where terms, nonlinear in the shear rate, are taken into account. The ensuing non-Newtonian viscosity and normal pressure differences are presented for a (stationary) plane Couette flow.

20971. Griffin, G. L.; Yates, J. T., Jr. Configurational effects in the adsorption of HD on ZnO, *Chem. Phys. Lett.* 87, No. 2, 201-203 (Mar. 19, 1982).

Key words: chemisorption; hydrogen; hydrogen deuterate; kinetic isotope effect; transition state; zinc oxide.

HD adsorption on ZnO surfaces has been studied by infrared spectroscopy as a function of ZnO temperature. At 300 K, the configuration Zn(H)-O(D) is preferred, as expected on thermodynamic grounds. As the temperature is lowered, the configuration Zn(D)-O(H) becomes preferred on kinetic grounds. This behavior is consistent with a model in which the transition state for HD adsorption is characterized by nearly complete dissociation of the H-D bond.

20972. Brown, D. W.; Lowry, R. E.; Smith, L. E. Hydrolytic degradation of polyester polyurethanes containing carbodiimides, *Macromolecules* 15, No. 2, 453-458 (Mar./Apr. 1982).

Key words: acid; carbodiimide; degradation; hydrolysis; kinetics; polyester; polyurethane.

Polyester polyurethanes containing a mono- or polycarbodiimide were aged at 100% relative humidity at 85, 55, and 35°C. Acid concentration, [A], carbodiimide concentration, [B], and the number-average molecular weight,  $M_n$ , were measured at intervals. Results are consistent with the occurrence of three parallel processes: acid-catalyzed hydrolysis, reaction of acid with carbodiimide, and uncatalyzed hydrolysis. Their rate constants are designated  $k$  (pseudo first order),  $k'$  (second order), and  $k_0$  (pseudo zero order), respectively. Pertinent differential equations are  $d[A]/dt = k_0 + k[A] - k'[A][B]$ ,  $d\Delta(M_n^{-1})/dt = k_0 + k[A]$ , and  $-(d[B]/dt) = k'[A][B]$ . The constants  $k$ ,  $k'$ , and  $k_0$  were calculated from the rates of scission and acid formation without carbodiimide, of mutual disappearance of A and B without water, and of long-term disappearance of B in the presence of water, respectively. These constants and the initial values of [A], [B], and  $M_n$  were inserted into the differential equations above and the equations were integrated digitally. The curves generated describe hydrolysis in the presence of monocarbodiimide reasonably well. Lifetimes, defined as the time required to accumulate a specific number of scissions, are increased 3-fold at 85°C, 7-fold at 55°C, and about 10-fold at 35°C by use of about 3 wt% monocarbodiimide. The polycarbodiimide is insoluble in the polyurethanes, and curves generated as described above do not fit the hydrolysis very well. By observation at 85°C the polycarbodiimide is about as effective as the

monocarbodiimide. The rate constant  $k_0$  is critical to the lifetime increment. It equals about  $10^{-6}$  equiv/(g-day) at 85°C and has an activation energy of about 85 kJ/mol.

20973. Arsenault, R. J.; deWit, R. Comments on non-spherical and spherical defect and screw dislocation interaction, *Scr. Metall.* 15, 615-617 (1981).

Key words: Burgers vector; defect; dislocation; glide; inclusion; kink; tetragonal.

With reference to a recent paper by Sato, Nakamura and Mori it is pointed out that there is a significant difference between the effects of a spherical and non-spherical defect on a screw dislocation. A couple force will always aid in the formation of a double kink irrespective of the spatial relationship of the interstitial and the screw dislocation line, whereas, a unidirectional force can aid or oppose the formation of a double kink depending upon the spatial relationship of the interstitial atom and the screw dislocation line. This couple force can lead to interstitial weakening, but unidirectional forces cannot.

20974. McLaughlin, W. L.; Humphreys, J. C.; Miller, A. Dosimetry for industrial radiation processing, *Proc. Meet. Traceability for Ionizing Radiation Measurements*, Gaithersburg, MD, May 8-9, 1980, H. T. Heaton, II, ed., pp. 171-178 (Center for Radiation Research, National Measurement Laboratory, National Bureau of Standards, Gaithersburg, MD 20234, Feb. 1982).

Key words: calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability.

In the dosimetry related to sterilization of goods by ionizing photons and electrons, and in other industrial radiation applications, i.e., modification of plastic and other materials, food preservation, and treatment of waste products, it is important to have traceability to standard absorbed dose measurements. The preferred primary methods of dosimetry for large radiation doses ( $>10$  Gy) are: (1) Calorimetry, which is suitable for both electron and photon radiations; (2) Standard chemical dosimetry, in particular, ferrous sulfate dosimetry, which, because of its relatively narrow response range (40-400 Gy) and rate dependence at dose rates  $>10^7$  Gys $^{-1}$ , is mainly suited to x- and gamma radiation. Using these techniques as primary reference methods, it is possible to calibrate the response characteristics of routine dosimeters, such as plastics, dyed plastics, and solid-state sensors in terms of a reproducible signal versus known values of absorbed dose. Dose levels and dose gradients within a sizable irradiated volume, e.g., product packages, are determined within specified values of uncertainty, which may be set in terms of statistical error and precision in making practical interpretation of dose and dose limits.

20975. Miller, A.; McLaughlin, W. L. Evaluation of radiochromic dye films and other plastic dose meters under radiation processing conditions, (Proc. Conf. High-Dose Measurements in Industrial Radiation Processing, Vienna, Austria, Sept. 25-29, 1978), *Tech. Rep. Ser.* 205, 119-138 (International Atomic Energy Agency, Vienna, 1981).

Key words: dosimetry; dyes; gamma radiation; plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; relative humidity effects; temperature effects.

Selection of dose meters for industrial irradiation purposes is mainly based on the specific dosimetry needs of the individual irradiation processes, weighed against knowledge of the well-documented behaviour of the dose meters in question. These selection criteria are briefly discussed. A comprehensive study is made of radiochromic dye dose meters with respect to the data needed in making a meaningful evaluation of their merits and faults. Part of the programme has been carried out for several types of radiochromic dye films, as well as red, amber and clear Perspex dose meters, and the results of these measurements are given.

20976. McRae, E. G.; Pierce, D. T.; Wang, G. C.; Celotta, R. J. Polarized-low-energy-electron-diffraction study of the mechanism of electron reflection from W(001) at low energies, *Phys. Rev. B* 24, No. 8, 4230-4239 (Oct. 15, 1981).



Key words: electron diffraction; polarized low energy; spin-orbit splitting; surface potential barrier tungsten (100); surface resonance.

Polarized-low-energy-electron-diffraction (PLEED) measurements on W(001) are reported for incidence conditions close to the (01) beam threshold [energies  $2 < E < 9$  eV, polar angles  $15^\circ < \theta < 45^\circ$ , (01) azimuth]. The intensity structure  $I(E)$  on the low-energy side of the threshold is found to depend on the spin polarization of the incident electrons. For  $\theta > 25^\circ$ , corresponding peaks in  $I^\uparrow(E)$  and  $I^\downarrow(E)$  are split in proportion to their width [symbols  $\uparrow(\downarrow)$  designate spin up (down) with respect to the scattering plane]. For  $\theta < 25^\circ$  the splitting-to-width ratio increases, and a shoulder grows up on the low-energy side of the lowest-energy peak of  $I^\uparrow(E)$ . The observations are explained by the superposition of reflection-amplitude contributions from "direct" or single scattering at the substrate and "indirect" processes in which the (01) beam is multiply reflected between the substrate and the surface-potential barrier. For  $\theta > 25^\circ$  the differences between  $I^\uparrow(E)$  and  $I^\downarrow(E)$  derive from the spin dependence of the phase of superposition of direct and indirect amplitude terms. The main effects come from the first indirect term, which corresponds to a single reflection at the surface potential barrier. For  $\theta < 25^\circ$  there are additional important contributions from higher-order indirect terms. These terms add coherently to produce a resonance perturbation of the line shape of  $I^\uparrow(E)$ . The present results, taken together with earlier LEED results, indicate that the threshold interference mechanism is the dominant mechanism of very low-energy ( $< 10$  eV) electron reflection at the W(001) surface.

20977. Kilmer, R. D. Safety sensor systems for industrial robots, *Proc. Conf. Robotics VI, Detroit, MI, Mar. 2-4, 1982*, pp. 479-491 (Robotics International of SME, One SME Drive, P.O. Box 930, Dearborn, MI 48128, 1982).

Key words: echo-ranging transducer; industrial robots; robots; safety; sensors; ultrasonic.

With the increased use of industrial robots comes the concern for providing safe operating conditions so that accidents are avoided. One potential solution is to provide sensor systems which can detect intruders that enter the work-station and signal the robot control system so that an appropriate control action can be taken. This paper discusses the development of a prototype safety system using sensors. The characteristics of these sensors are discussed and a description of the application of this system to one of the NBS research robots is presented.

20978. Marshak, H. Nuclear orientation of  $^{166}\text{Ho}$  in  $^{165}\text{Ho}$  single crystal, *Hyperfine Interact.* 10, Nos. 1-4, 1183-1188 (June 1981).

Key words: mixing ratios; nuclear magnetic moment; nuclear orientation; nuclear quadrupole moment;  $\gamma$ -ray anisotropy thermometry;  $\gamma$ -ray transitions in  $^{166}\text{Er}$ ;  $^{166}\text{Ho}$ .

Nuclear orientation measurements have been made on the system  $^{166}\text{Ho}$  in single crystal  $^{165}\text{Ho}$  metal. Our results for the nuclear magnetic moment,  $\mu_{\text{nm}} = 3.65(13)$  nm is in excellent agreement with the recent results by the Oxford group in their work on  $\text{HoVO}_4$ . We also report on the use of  $^{166}\text{mHo}$  as a  $\gamma$ -ray anisotropy thermometer.

20979. Roder, H. M. The  $\text{H}_2$  (hydrogen) system, *Bull. Alloy Phase Diagrams* 2, No. 3, 362-366 (1981).

Key words: crystal structure; hydrogen; phase diagram; properties; solid.

A brief description of the phase diagram, of the crystal structure of solid hydrogen is given at both moderate and extreme pressures. Physical, mechanical and thermal properties of the solid which are of immediate interest to the metallurgist are included.

20980. Hayward, R. W. The macroscopic harmonic oscillator and quantum measurements, *Proc. Second Marcel Grossmann Meet. General Relativity, Trieste, Italy, July 5-11, 1979, Part B*, R. Ruffini, ed., pp. 977-1004 (North-Holland Publ. Co., 335 Jan Van Galenstraat, P.O. Box 103, Amsterdam-W, The Netherlands, 1982).

Key words: gravitational wave detector; harmonic oscillator; precision measurements; quantum limits; quantum nondemolition; quasi-coherent states.

A quantum mechanical description of a one-dimensional macroscopic harmonic oscillator interacting with its environment is given. Quasi-coherent states are introduced to serve as convenient basis states for application of a density matrix formalism to characterize the system. Attention is given to the pertinent quantum limits to the precision of measurement of physical observables that may provide some information on the nature of a weak classical force interacting with the oscillator. A number of "quantum nondemolition" schemes proposed by various authors are discussed.

20981. Sonnefeld, W. J.; Zoller, W. H.; May, W. E.; Wise, S. A. On-line multidimensional liquid chromatographic determination of polynuclear aromatic hydrocarbons in complex samples, *Anal. Chem.* 54, No. 4, 723-727 (Apr. 1982).

Key words: determination of benzo[a]pyrene; multidimensional chromatographic analysis; on-line sequential liquid chromatographic analysis; polynuclear aromatic hydrocarbons; shale oil analysis; solvent refined coal.

A method is described for the on-line coupling of a normal-phase high-performance liquid chromatographic (HPLC) system to a reversed-phased HPLC system. The method employs a diamine column for on-column concentration of a selected fraction from a normal-phase aminosilane column followed by a solvent exchange procedure and gradient elution focusing of the analyte species onto a reversed-phase octadecylsilane column. No loss of analyte of chromatographic resolution is observed by using this method. Several chromatographic packing materials were investigated for use as on-column concentrators of polynuclear aromatic hydrocarbons (PAH) from normal-phase chromatographic systems. The validity of this approach was verified by determining the concentration of several PAH in Standard Reference Material (SRM) 1580—"Organics in Shale Oil."

20982. Sjölin, L.; Wlodawer, A. Improved technique for peak integration for crystallographic data collected with position-sensitive detectors: A dynamic mask procedure, *Acta Crystallogr.* A37, 594-604 (1981).

Key words: diffractometry; macromolecular crystallography; neutrons; position-sensitive detectors; precision of data; x rays.

A technique for improving the precision of crystal data collected on films or with electronic position-sensitive detectors is proposed. The extent of each medium or strong reflection is computed independently, after smoothing and filtering the individual intensities, producing a variable 'dynamic mask'. A method of calculating universal background profiles, which preserves the data and limits the necessary storage, is introduced. The method was applied to data collected with X-ray precession and oscillation techniques and to neutron data collected with a flat-cone diffractometer equipped with a linear detector. In all cases substantial improvement in the precision of weaker reflections was observed. The overall quality of the data was particularly enhanced in the neutron diffraction case.

20983. Kroll, M. Saturation spectroscopy and resonant degenerate four-wave mixing in Hg at 546.1 nm, *Opt. Lett.* 7, No. 4, 151-153 (Apr. 1982).

Key words: atomic mercury; degenerate four-wave mixing; excited state spectrum; saturation spectrum.

Doppler-free saturation spectroscopy performed in an rf discharge in mercury vapor has made it possible to identify clearly all the central components of the 546.1-nm transition. Resonant degenerate four-wave mixing has also been observed in this system at this wavelength.

20984. Albers, J. Probe-spacing experiment simulation and the relation between spreading resistance and sheet resistance, *J. Electrochem. Soc.* 129, No. 3, 599-605 (Mar. 1982).

Key words: multilayer Laplace equation; probe spacing; sheet resistance; spreading resistance.

Recently, Dickey has proposed that the two-probe spreading resistance measured on the surface of a thin, nonuniform, junction-isolated layer is a linear function of the natural logarithm of the probe



separation with a slope proportional to the sheet resistance and an intercept related to the probe radius. Model spreading resistance data generated from the multilayer solution of Laplace's equation were used to test the validity of this relation between spreading resistance and sheet resistance. The model data were meant to simulate diffusions or implants into same conductivity type as well as junction-isolating substrates. For a junction-type structure, the model data indicate that probe-spacing experiments will yield the correct sheet resistance in the surface region, but that the intercept is not related to the radius. The same conclusion is obtained for a heavily doped layer over a substrate of the same conductivity type. For lightly and moderately doped layers over a substrate of the same conductivity type, the relation between the spreading resistance and the sheet resistance is found not to hold.

**20985.** Fine, J.; Navinsek, B.; Davarya, F.; Andreadis, T. D. **Sputter depth profiles of Ni/Cr thin-film structures obtained from the emission of Auger electrons and x rays**, *J. Vac. Sci. Technol.* **20**, No. 3, 449-452 (Mar. 1982).

**Key words:** Auger spectroscopy; depth profiling; sputtering; surface analysis; thin films; x-ray spectroscopy.

Multilayered thin-film Ni/Cr/Ni/Cr... structures, prepared by sputter deposition, were depth profiled by argon ion sputtering at energies of both 1 and 3 keV. Compositional depth profiles were obtained by simultaneously detecting the characteristic emission of Auger electrons and x rays that results from bombardment with 5-keV primary electrons. An ultra-thin windowed energy-dispersive Si(Li) detector was used to monitor the emitted *La* x rays of Ni(0.85 keV) and Cr(0.57 keV). Due to the use of a near-grazing take off angle for x rays, the x-ray "probe depth" for 5-keV primary electrons is somewhat greater than the thickness of an individual thin film (~70 nm) and results in an x-ray profile generated by the amount and type of material contained in such a layer thickness. Both Auger and x-ray measurements indicate that each sputtered film is completely resolved, that little degradation in the interface widths is observed in sputtering through all nine layers of the structure, and that determinations of sputtering times based on Ni/Cr periodicity as well as on single film removal are remarkably consistent. The well-defined repetitive profiles indicate that this multilayered material may be well suited for use in sputter depth calibration. In combining x-ray analysis with Auger spectroscopy, the additional information obtained can be very effective in thin-film analysis.

**20986.** Powell, C. J.; Erickson, N. E.; Jach, T. **Summary abstract: Accurate determination of the energies of Auger electrons and photoelectrons from nickel, copper, and gold**, *J. Vac. Sci. Technol.* **20**, No. 3, 625 (Mar. 1982).

**Key words:** Auger electrons; copper; gold; nickel; photoelectrons; surface analysis.

A summary is given of new measurements of absolute kinetic energies of Auger electrons and photoelectrons from nickel, copper, and gold.

**20987.** Semancik, S.; Kelley, R. D. **The effects of Fe on the reactivity of Ni(100)**, *J. Vac. Sci. Technol.* **20**, No. 3, 823-826 (Mar. 1982).

**Key words:** carbon monoxide; catalytic activity; dissociation; hydrogen; iron; Ni(100).

High pressure reaction methods have been combined with ultrahigh vacuum techniques to investigate the influence of low level Fe on the catalytic activity of the Ni(100) surface. CO dissociation and hydrocarbon formation from H<sub>2</sub>/CO mixtures are the specific reactions which have been considered. Reactivity changes observed in the presence of surface Fe can be attributed to the different local chemistry involved in CO-Fe and CO-Ni interactions.

**20988.** Bean, V. E.; Akimoto, S.; Bell, P. M.; Block, S.; Holzapfel, W. B.; Jamieson, J. C.; Manghnani, M. H.; Nicol, M. F.; Piermarini, G. J.; Stishov, S. M. **Toward an International Practical Pressure Scale: An AIRAPT task group report**, *Proc. 8th Conf. Int. Assoc. Advancement of High Pressure Science and Technology and the 19th Conf. European High Pressure Research Group, Uppsala, Sweden, Aug. 17-22, 1981*, C. M. Backman, T. Johannisson, L. Tegner, eds., **1**, 144-151 (Arkitektopia, Uppsala, Sweden, 1982).

**Key words:** calibration; measurement; metrology; pressure; pressure scale; standards.

The International Association for the Advancement of High Pressure Research and Technology has established a task group with the charge to examine what recommendations could be made with regard to an International Practical Pressure Scale. This task group report is a review of high pressure metrology with recommendations at the conclusion.

**20989.** Booker, R. L. **Specular UV reflectance measurements for cavity radiometer design**, *Appl. Opt.* **21**, No. 1, 153-157 (Jan. 1, 1982).

**Key words:** absorption coefficient; black paint; deuterium lamp; silicon photodiode; specular reflectance; ultraviolet reflectance.

Specular reflectance measurements were made on a black paint used in a solar constant monitoring cavity radiometer. Interference filters peaking at 180, 200, and 220 nm were used in conjunction with a deuterium lamp source and a silicon photodiode detector. Results showed that the black paint was specular for light incident 60° from normal and it reflected ~8% of the light at these wavelengths. We conclude that the high absorptance of the radiometer calculated for visible wavelengths should remain valid down to ~190-nm UV wavelengths.

**20990.** Becker, D. A. **Re-refined lubricating base oils: Establishing consistency and quality**, *1980 Proc. Refining Department 45th Midyear Meet., Houston, TX, May 12-15, 1980*, **59**, 1-5 (American Petroleum Institute, New York, 1980).

**Key words:** basestock; engine lubricants; lubricating oil; motor oil; petroleum oil; recycled oil; re-refined oil; test procedures.

The National Bureau of Standards' (NBS) Recycled Oil Program was established in 1976, in direct response to the Energy Policy and Conservation Act (42 U.S.C. 6363(c); P.L. 94-163). This Act requires NBS to develop test procedures "...for the determination of substantial equivalency of re-refined or otherwise processed used oil...with new oil for a particular end use..." and to report such test procedures to the Federal Trade Commission (FTC) as soon as practicable. Initial NBS efforts were on test procedures for recycled oil used as burner fuel, and a report on these was transmitted to the FTC on November 20, 1978. Immediately thereafter, work was initiated on the second phase of the NBS program, on re-refined oil to be used as motor oil. Significant progress has been made in this second phase, although substantial research and development remains and is in progress.

**20991.** Blair, J. C. **Continuous signal-controlled squelch systems**, *NIJ Standard-0219.00*, 20 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Aug. 1980).

**Key words:** decoder; digital controlled; encoder; law enforcement standard; selective signaling; squelch systems; tone-coding.

This document is a law enforcement equipment performance standard developed by the Law Enforcement Standards Laboratory. It provides performance requirements and test methods for continuous tone-controlled squelch systems (CTCSS) with tone frequencies below 300 Hz and for continuous digital-controlled squelch systems (CDCSS) with binary data rates less than 150 baud. The standard lists the principal terms and definitions needed to use the document and provides test methods to measure the 12 primary characteristics of CTCSS systems and 10 primary characteristics of CDCSS systems. It further provides for testing 10 of these characteristics under varying environmental extremes. Some of the characteristics measured are code frequency and data rate, code frequency stability, encoder response time and transmitter tone distortion.

**20992.** Younger, S. M. **Electron impact ionization rate coefficients and cross sections for highly ionized iron**, *J. Quant. Spectrosc. Radiat. Transfer* **27**, No. 5, 541-544 (1982).

**Key words:** distorted wave scattering theory; electron impact ionization of ions; iron.

Electron impact ionization cross sections for the ions



Fe(XVII)–(XXVI) have been computed in a distorted wave exchange approximation. Analytic fits are provided for the cross section data, as well as for the rate coefficients assuming a Maxwellian electron velocity distribution. For ejection of a  $2p$  ground state electron, the scaled ionization rate was found to depend linearly on the number of  $2p$  electrons in the ion.

**20993.** Brosch, N.; Shaviv, G. **Multiperture photometry of isolated galaxies**, *Astrophys. J.* **253**, No. 2, 526-538 (Feb. 15, 1982).

Key words: galaxies, photometry; galaxies, stellar content; galaxies, structure.

Multiperture  $U$ ,  $B$ ,  $V$  photometry of isolated galaxies by Huchra and Thuan shows a behavior different from normal field galaxies in that the inner regions of the isolated galaxies appear to have excess blueness similar to galaxies with active nuclei. The implication of this finding is that gas, which does not escape from isolated galaxies sinks into the nucleus and gives rise to nonstellar radiation.

**20994.** Moore, R. T. **GRIDNET simulation**, *Proc. 1982 Carnahan Conf. Security Technology, University of Kentucky, Lexington, KY, May 12-14, 1982*, pp. 31-36 (OES Publications, 226 Anderson Hall, University of Kentucky, Lexington, KY 40506, May 1982).

Key words: alternate routing; communications networks; distributed control; message delay; network throughput; survivability.

Simulation results for a highly reliable and survivable data communication system are described. The network is called GRIDNET and is formed by the multiple interconnection of large numbers of dual, fiber optic loops. This provides many alternate routes for the transmission of messages between stations that occupy different positions on the network. The intelligence required for the control of communications and the routing of traffic is distributed among the gateway stations that serve to interconnect the loops. These gateway stations select the most direct route from source to destination for a message when the network is intact, and select alternate routes around failures. Only limited local knowledge of operability status is required by the gateways for routing, and the resulting limited demands for bandwidth permit the network to serve many thousands of stations. Network survival is not dependent upon the survival of any node or link, and a message will reach its destination as long as any operable path to that destination exists.

Computer simulations of the GRIDNET have been conducted. Examples of route finding around outages are shown, together with simulation results showing system throughput and delay characteristics.

**20995.** Hurley, W.; May, W.; Kelly, G.; Borresen, B. **Direct digital control of an air handler**, *Proc. EMCS Sixth Energy Management and Controls Society Conf., Houston, TX, Nov. 4-7, 1981*, pp. i, 1-18 (EMCS Secretariat, Driscoll & Associates, 1925 North Lynn Street, Suite 1002, Arlington, VA 22209).

Key words: building controls; digital-to-pneumatic conversion; direct digital control; energy controls; HVAC system; microprocessor control; pneumatic control system; velocity algorithm.

A microprocessor-based direct digital controller employing a PI algorithm has been used to perform local loop control on a large air handling unit in an office-laboratory building at the National Bureau of Standards in Gaithersburg, Md. The controller has successfully held the supply air temperature from the air handling unit at desired setpoints over a period of several months. Two methods used for interfacing the digital controller to the existing pneumatic control system are described. Problems encountered with air leaks in the existing pneumatic control system and their effect on the control of the supply air temperature are discussed for each type of digital-to-pneumatic interface.

The direct digital controller, which is located at the air handler, was programmed from a central microcomputer also used to monitor and record data. The software, PI control algorithm, and the selection of control parameters are discussed. Experimental results are presented for a number of different tests involving set-point changes and the effect of induced leaks. In addition, on-going experiments involving direct digital control of air handlers are discussed, along with a brief overview of NBS' future research program in the

building controls area.

**20996.** Blaha, J. J.; Rosasco, G. J. **Raman microprobe characterization of urea:  $n$ -paraffin inclusion compounds**, *J. Raman Spectrosc.* **11**, No. 2, 75-80 (1981).

Key words: hexagonal urea lattice; inclusion compounds; microanalysis; normal alkanes; Raman microprobe; Raman spectroscopy; vibrational analysis.

Urea: $n$ -paraffin inclusion compounds have been formed through sonification of urea with pure paraffin liquids. Raman microprobe spectra of individual microcrystals ( $5\text{--}50\text{ }\mu\text{m}$  in size) of these materials are interpreted in terms of a non-planar conformation for the included paraffins. A series of *trans* and *gauche* bonds is shown to yield a conformation of the included alkane that preserves the full symmetry of the hexagonal urea host. The urea host lattice spectrum thereby shows additional sharp bands consonant with a more highly ordered host lattice. These observations are contrasted to the case of the *trans*-planar conformation normally encountered and verified in this work for urea: $n$ -paraffin inclusion compounds prepared from solution.

**20997.** Becker, D. A.; Rook, H. L.; LaFleur, P. D. **High purity materials, standards, and reference materials**, Chapter 5, Section 4, *Studies in Analytical Chemistry 3, Nondestructive Activation Analysis*, Saadia Amiel, ed., pp. 237-258 (Elsevier Scientific Publ. Co., Amsterdam, 1981).

Key words: accuracy; high purity materials; instrumental neutron activation analysis; precision; reference materials; standards; trace analysis.

This is a chapter section which covers utilization of instrumental neutron activation analysis for the analysis of pure materials, and the proper use of standards and reference materials for trace element analyses with this technique. Also provided is an up-to-date listing of most of the readily available reference materials, including NBS SRM's.

**20998.** Schindler, M.; Stencel, R. E.; Linsky, J. L.; Basri, G. S.; Helfand, D. J. **Ultraviolet and x-ray detection of the 56 Pegasi system (K0 IIp+WD): Evidence for accretion of a cool stellar wind onto a white dwarf**, *Astrophys. J.* **263**, 269-276 (Dec. 1, 1982).

Key words: stars, Ba II; stars, individual; stars, late-type; stars, white dwarfs; stars, winds; ultraviolet, spectra.

IUE spectra of the slowly rotating mild barium star 56 Peg (HD 218356; K0 IIp) show excess continuum emission from 1300 to 2000 Å, a broad Ly $\alpha$  absorption feature, and emission lines usually associated with a  $10^4\text{--}(2\times 10^5)$  K plasma. The best fit blackbody curve to the dereddened continuum gives a temperature of  $32,000\pm 4000$  K and a radius for the object of  $(2.7\pm 1.0)\times 10^9$  cm, consistent with that of a white dwarf. Einstein IPC observations of this system yield  $L_x\approx 3\times 10^{31}$  ergs s $^{-1}$ , which is as bright as the RS CVn binary systems. The X-rays can be fitted to a bremsstrahlung spectrum with  $kT=0.45\pm 0.3$  keV, or a blackbody spectrum with  $kT\approx 0.2$  keV. Since bright X-ray and high temperature emission lines are unusual for single stars in this region of the H-R diagram, we do not believe that the 56 Peg primary has a hot corona and transition region. Instead, we propose that the observed X-ray luminosity is due to accretion onto the white dwarf of  $\sim 0.1\%$  of the wind from the primary, which we assume has a reasonable mass loss rate of  $2\times 10^{-7}$  to  $4\times 10^{-9}$   $M_\odot$  yr $^{-1}$ . The ultraviolet emission lines likely result from reprocessed X-radiation absorbed by the wind. The Mg II K line exhibits a time-varying emission core, that may be explained by ionization of Mg $^{+}$  in the wind by X-rays from the white dwarf.

**20999.** Blair, W. R.; Jackson, J. A.; Olson, G. J.; Brinckman, F. E.; Iverson, W. P. **Biotransformation of tin**, *Proc. Third Int. Conf. on Heavy Metals in the Environment, Amsterdam, The Netherlands, Sept. 14-18, 1981*, pp. 235-242 (CEP Consultants, Edinburgh, Great Britain, Sept. 1981).

Key words: atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin.



The first evidence for the bacterial methylation of tin from inorganic Sn(IV) was presented in 1973 and recently has been verified by other investigators. Recent studies with *Pseudomonas* strain 244, first employed in the initial observations, have indicated that the volatile methylated species produced by this organism from Sn(IV) and to a considerably lesser extent from Sn(II), include tetramethyltin ( $\text{Me}_4\text{Sn}$ ) and a number of hydridic methylstannanes ( $\text{Me}_n\text{SnH}_{4-n}$ ,  $n=2,3$ ). Subsequently, using hydridization coupled with a new purge/trap gas chromatographic method, methylated tin compounds (methylstannanes) have been found in the Chesapeake Bay, as both volatile and non-volatile species [ $(\text{CH}_3)_n\text{SnH}_{4-n}$  and  $(\text{CH}_3)_n\text{Sn}^{(4-n)+}$ , respectively]. Concentrations have ranged from 0 to 930 ng L<sup>-1</sup>. Studies on the biological transformation of organotin compounds have so far indicated that there are no significant biotransformations of tributyltin moiety,  $\text{Bu}_3\text{Sn}^+$  (TBT). TBT-resistant organisms from the Chesapeake Bay were found to accumulate tributyltin. This accumulation did not appear to be an energy requiring process, since glucose did not significantly stimulate starved cells to accumulate tin.

**21000.** Blackburn, D. L.; Robbins, T. C.; Galloway, K. F. **VDMOS power transistor drain-source resistance radiation dependence**, *IEEE Trans. Nucl. Sci.* NS-28, No. 6, 4354-4359 (Dec. 1981).

Key words: drain-source resistance; electron devices; gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; power transistors; radiation effects; semiconductor devices; VDMOS.

Data on the effects of neutron and gamma radiation on the drain-source resistance characteristics of power VDMOS transistors are presented. The change in resistance with neutron exposure is related to the resistivity of the drain material, which in turn can be related to the drain-source breakdown voltage. A device with a 450-V rating experienced a factor of 13 increase in resistance on exposure to a neutron fluence of  $10^{14}/\text{cm}^2$  whereas one with a breakdown voltage of 150 V experiences no increase in resistance. Threshold voltage shifts of about 2 V occurred at a gamma dose of  $10^5$  rad(Si) without bias and was accelerated by positive gate bias. All of these data are consistent with the predictions of a simple model for the dependence of drain-source resistance on gate voltage and drain resistivity. This model illustrates a general separability of neutron and gamma effects on power VDMOS devices. The systems implications for using this type device in a radiation environment are briefly addressed.

**21001.** Hall, J. L.; Hollberg, L.; Long-sheng, M.; Baer, T.; Robinson, H. G. **Progress toward phase-stable optical frequency standards**, *J. Phys. Colloq.* C8, No. 12, C8-59-C8-71 (Dec. 1981).

Key words: laser frequency standards; laser stability; optical frequency standards.

The sensitivity of laser spectroscopy is usually limited by laser amplitude noise of a technical nature. We describe a new and very sensitive detection technique which basically eliminates this source of noise by encoding the resonance information into RF frequencies using FM modulation followed by optical heterodyne and RF phase-sensitive detection. The method is applied to laser stabilization and sub-Doppler spectroscopy. Calculation shows the method provides an available sensitivity within 3.4 dB of the theoretical limit for ideal absorption spectroscopy.

**21002.** Pitchford, L. C.; Phelps, A. V. **Comparative calculations of electron-swarm properties in  $\text{N}_2$  at moderate  $E/N$  values**, *Phys. Rev. A* 25, No. 1, 540-554 (Jan. 1982).

Key words: diffusion; drift velocity; electrons; excitation; nitrogen; numerical calculation; transport.

The recently developed density gradient and multiterm spherical harmonic expansion technique for the numerical solution of the electron Boltzmann equation is evaluated by comparison of results with those obtained using the conventional two-term spherical harmonic technique and using the Monte Carlo technique. Comparisons are made of electron energy distributions, transport coefficients, and excitation coefficients for electrons in  $\text{N}_2$  at moderate electric-field to gas-density ratios  $E/N$  where the large cross section for vibrational excitation leads to significant errors when conventional solutions of the Boltzmann equation are used. The  $E/N$  values were varied from  $(1-200) \times 10^{-21}$  V m<sup>2</sup>, corresponding to mean electron energies from 0.3 to 5 eV. The first two terms of the density-gradient

expansion are used. As the number of terms  $n$  in the spherical harmonic expansion is increased from the conventional two terms to  $n > 4$ , the spherically symmetric component of the electron energy distribution and the transport and excitation coefficients become independent of  $n$  and close to results obtained from the Monte Carlo calculation. The errors resulting from the use of two spherical harmonics at  $E/N = 7 \times 10^{-20}$  V m<sup>2</sup>, for example, are approximately 1, 5, and 30% for the drift velocity, the transverse diffusion coefficient, and the electronic excitation coefficients, respectively. For the lower  $E/N$  values the errors in the transport coefficients are approximately proportional to an energy-loss-per-collision parameter. The variation of the coefficients of the lower-degree terms in the spherical-harmonic expansion with  $n$  is examined through a comparison with an analytical solution of the Boltzmann equation for a model atom valid in the case of low  $E/N$  and high electron energies. Monte Carlo techniques are used to show that the effects of electrodes are negligible for the conditions of recent measurements of electron excitation coefficients in  $\text{N}_2$ .

**21003.** Leuchs, G.; Smith, S. J. **Five-photon non-resonant photoionisation of atomic sodium—The angular distribution of photoelectrons**, *J. Phys. B: At. Mol. Phys.* 15, No. 7, 1051-1059 (1982).

Key words: atomic sodium; high power laser; ionization; multiphoton; nonresonant.

We report a measurement of the photoelectron angular distribution in non-resonant multiphoton ionisation of atomic sodium. Linearly polarised Nd:YAG laser radiation was used to ionise ground ( $3^2\text{S}_{1/2}$ ) state sodium atoms in a non-resonant five-photon process. The angular distribution observed contains significant contributions of trigonometric functions of the type  $\cos(2mx)$  up to  $m=5$ . The absolute ionisation cross section is compared with previous measurements.

**21004.** Arens, E.; Zeren, L.; Gonzalez, R.; Berglund, L.; McNall, P. E. **A new bioclimatic chart for environmental design**, (Proc. Int. Congress, Povo de Varzim, Portugal, May 12-16, 1980), Paper in *Building Energy Management*, E. De Oliveira Fernandes, J. E. Woods, and A. P. Faist, eds., pp. 645-657 (Pergamon Press, Great Britain, 1981).

Key words: bioclimatic chart; human comfort; indoor environment; outdoor environment; thermal comfort.

The "bioclimatic chart" developed in the 1950's by Olgyay is revised, using the latest available research on human response to the thermal environment. The chart shows the various combinations of air temperature, humidity, radiation (from the surroundings and the sun) and wind or air motion, which provide thermally acceptable conditions for average people, clothed for the average indoor winter conditions and slightly active. The chart extends the usual indoor conditions to those outdoors, with much greater differences among the thermal properties, so that indoor and outdoor conditions can be reasonably controlled for comfort purposes through architectural design or with simple mechanical equipment.

**21005.** Stockbauer, R. L.; Hanson, D. M.; Flodström, S. A.; Madey, T. E. **Summary abstract: The interaction of  $\text{H}_2\text{O}$  with a Ti(001) surface as studied by photon stimulated desorption and ultraviolet photoemission spectroscopy**, *J. Vac. Sci. Technol.* 20, No. 3, 562-563 (Mar. 1982).

Key words: hydrogen; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; water.

Synchrotron radiation at the NBS SURF II facility ( $15 \text{ eV} < h\nu < 75 \text{ eV}$ ) has been employed to study the adsorption of  $\text{H}_2\text{O}$  on a stepped Ti single crystal surface, oriented within  $4^\circ$  of Ti(001). The adsorption behavior was characterized using ultraviolet photoemission spectroscopy (UPS), photon stimulated desorption (PSD) and electron stimulated desorption (ESD). A cylindrical mirror analyzer was used for energy analysis of both electrons and ions, as well as for ion mass analysis using a time-of-flight method. The UPS measurements indicate that  $\text{H}_2\text{O}$  dissociates at 300 K to form a mixed layer of H, O, and OH; emission from orbitals characteristic of molecular  $\text{H}_2\text{O}$  is not seen. At 90 K, the UPS results show that  $\text{H}_2\text{O}$  dissociates on Ti(001) at exposures less than 1 L, but features due to



molecular  $\text{H}_2\text{O}$  grow in at higher exposures.

- 21006.** Parr, A. C.; Ederer, D. L.; West, J. B.; Holland, D. M. P.; Dehmer, J. L. Triply differential photoelectron studies of non-Franck-Condon behavior in the photoionization of acetylene, *J. Chem. Phys.* **76**, No. 9, 4349-4355 (May 1, 1982).

Key words: acetylene; angular distribution; photoionization; synchrotron radiation.

Vibrational branching ratios and photoelectron angular distributions for alternative vibrational levels of  $\text{C}_2\text{H}_2^+ X^2\Pi_u$  have been measured in the range  $13 \text{ eV} \leq h\nu \leq 25 \text{ eV}$  using synchrotron radiation. Below  $h\nu \sim 16 \text{ eV}$ , these data exhibit strong non-Franck-Condon effects, namely, wavelength-dependent vibrational branching ratios, and vibrational-state-dependent photoelectron asymmetry parameters. Moreover, enhanced excitation of bending modes of the ion is observed below  $h\nu \sim 16 \text{ eV}$ , in addition to the C-C stretch mode, which is the only mode readily observed in photoelectron spectra of  $\text{C}_2\text{H}_2$  at shorter wavelengths, e.g., at the He I (21.2 eV) resonance line. The non-Franck-Condon behavior is attributed to resonant photoionization processes, whose identification is discussed in the framework of several recent theoretical and experimental studies on acetylene and related molecules.

- 21007.** Guillot, B.; Bratos, S.; Birnbaum, G. Theoretical study of collision-induced far-infrared absorption of dense rare-gas mixtures, *Phys. Rev. A* **25**, No. 2, 773-781 (Feb. 1982).

Key words: absorption spectrum; atomic masses; collision-induced absorption; concentration; correlation function; density; rare gas mixtures; spectral behavior.

A theory investigating collision-induced absorption in dense rare-gas mixtures is presented. The basic assumption of the theory is that the collision-induced dipole moment of a pair of dissimilar atoms is proportional to the force acting between them. It is then shown that the relevant dynamical variable is the interdiffusion current fluctuation,  $\mathbf{J} = (1-x) \sum_i^N \mathbf{A}_i \nabla_i - x \sum_i^N \mathbf{B}_i \nabla_i$ , in the fluid mixture. The correlation function and absorption spectrum are generated by the Zwanzig-Mori theory of Brownian motion. Two modes are theoretically predicted. A diffusive mode, due to the mutual diffusion of rare-gas atoms, produces a low-frequency dip in the line shape whereas an oscillatory mode, due to the oscillations of atoms in the local structure of the fluid, generates a caging spike in the wing of the spectrum. Spectral behavior is shown to depend on density, concentration, and atomic masses of the two components of the mixture and is discussed in detail.

- 21008.** Cohen, G. G.; Deslattes, R. D. Application of a high intensity laboratory x-ray source to EXAFS spectroscopy, *Nucl. Instrum. Methods* **193**, 33-39 (1982).

Key words: crystal focusing; laboratory EXAFS.

A practically oriented summary for the design and operation of a high-performance laboratory EXAFS system is presented. Emphasis is on an evaluation of total system performance, including both geometrical and crystal diffraction effects.

- 21009.** Kelley, R. L.; Rappaport, S.; Brodheim, M. J.; Cominsky, L.; Stothers, R. A search for apsidal motion in 4U0115+63, *Astrophys. J.* **251**, No. 2, 630-638 (Dec. 15, 1981).

Key words: pulsars; stars, individual; x rays, binaries.

We have carried out a pulse arrival-time analysis of the archival *Uhuru* data from the 1971 transient outburst of the binary X-ray pulsar 4U0115+63. The 3.6 s X-ray pulsations are clearly present in the data, and we show that the average fractional rate of change in pulse period over the 7 yr interval 1971-1978 corresponds to  $\dot{P}/P = -2 \times 10^{-6} \text{ yr}^{-1}$ . This spin-up rate is consistent with an average source luminosity  $\sim 20$  times less than that observed during its flare state. The pulse arrival times were tracked for  $\sim 7^d$ , and by combining these data with the 1978 *SAS 3* orbital determination, we place a limit on the advance of periastron in the 4U0115+63 system of  $\dot{\omega} \leq 2^{\circ} 1 \text{ yr}^{-1}$  (95% confidence). The analysis also yields an improved value for the orbital period,  $P_{\text{orb}} = 24^d 31.62$ . The constraints on the companion star imposed by the limit on apsidal motion are discussed.

- 21010.** Rappaport, S.; Joss, P. C.; Webbink, R. F. The evolution of highly compact binary stellar systems, *Astrophys. J.* **254**, No. 2, 616-640 (Mar. 15, 1982).

Key words: binary stellar evolution; cataclysmic variables; compact binary x-ray sources; gravitational radiation decay of binary orbits.

We have calculated the evolution of close binary stellar systems composed of a collapsed star and a low-mass companion in an orbit with a period of  $\sim 3$  hours or less at the onset of mass transfer. The low-mass (secondary) star is assumed to transfer mass onto the collapsed (primary) star due to the decay of the orbit resulting from gravitational radiation. Under these circumstances, the secondary is well represented by an  $n=3/2$  polytrope. By utilizing this approximation, we are able to explore the effects of varying a number of physical parameters, including the stellar masses, the composition of the secondary, and mass and angular momentum losses from the system. Moreover, we are able to follow the evolution until the secondary has been almost completely consumed. For a wide range of parameters, even with extreme angular momentum losses (as long as those losses are proportional to the mass transfer rate), the transfer rate for a large portion of the evolution is tightly constrained to  $\leq 10^{-10} M_{\odot} \text{ yr}^{-1}$ , in good agreement with the rates inferred from many cataclysmic variables.

At very short orbital periods, the Kelvin time of the secondary becomes larger than the gravitational radiation time scale, and the secondary is driven out of thermal equilibrium. At this stage, the binary reaches a minimum orbital period,  $P_{\text{min}}$ , of typically  $\sim 60$ -75 minutes as the secondary cools toward a degenerate configuration. We identify  $P_{\text{min}}$  with the short-period cutoff in the orbital period distribution among cataclysmic variables, and we quantify the dependence of  $P_{\text{min}}$  on the physical parameters of the system. We also discuss the possible importance of irradiation by the accreting primary star to the evolution of the secondary. The divergence of the secondary from thermal equilibrium near the minimum period leads to systematic overestimation of component masses in cataclysmic variables under some commonly used assumptions. We present some simple expressions with which to estimate this effect. We find that among the ultrashort-period cataclysmic variables, as many as 20% of the observed systems may contain degenerate secondaries.

Binaries of the type modeled here with neutron-star primaries provide a natural explanation for the intermediate-luminosity galactic bulge X-ray sources. However, we find that it is very difficult to sustain mass transfer rates high enough to power the brightest galactic bulge X-ray sources, unless they contain hydrogen exhausted secondaries.

- 21011.** Itano, W. M.; Wineland, D. J. Laser cooling of ions stored in harmonic and Penning traps, *Phys. Rev. A* **25**, No. 1, 35-54 (Jan. 1982).

Key words: atomic spectroscopy; ion trap; laser cooling; light pressure; Penning trap; quadrupole rf trap.

Laser (light-pressure) cooling of two-level ions stored in a Penning trap is treated theoretically, in the limit that the frequencies of motion of the ions are much smaller than the natural linewidth of the optical transition. Rate equations for the mean-squared amplitudes of motion are derived from a semiclassical analysis, which is confirmed by quantum-mechanical perturbation theory. Simultaneous cooling of all three modes of motion is shown to require a spatially nonuniform laser-beam profile, unlike the case of the harmonic trap. Comparison is made with recent experiments. Also, the three-dimensional harmonic trap is treated by two simple methods. One is based on the energy rate equations and the other on Langevin-type equations. Identical results are obtained by the two methods for the steady-state energies. These results are compared with the works of others.

- 21012.** Egelhoff, W. F., Jr. Electronic structure evolution of Au, Ag, and Cu deposited on Al(100), *J. Vac. Sci. Technol.* **20**, No. 3, 668-670 (Mar. 1982).

Key words: aluminium; clusters; copper; gold; silver; single crystal; thin films.

The evolution of the electronic structure of Au, Ag, and Cu from submonolayer coverages up to bulk metal has been studied by XPS on an Al(100) substrate. The ordering of the overlayers is monitored by LEED. All three elements share the common feature that the



electronic structure, as determined by the core level binding energies and the shape of the valence band, do not converge on their bulk values until a thickness of about 10 to 20 monolayers. Since this is drastically different from theoretical calculations indicating convergence around 4 layers thickness, it is clear that the overlayer growth mode is drastically different from a layer-by-layer structure. Analysis of the data indicates that the structure probably consists of tightly packed clusters with a diameter approximately equal to the thickness of the film. These systems thus represent an intermediate case between agglomeration into very large clusters (which occurs when the bonding between overlayer and substrate is weak) and a layer-by-layer growth mode (which occurs when the overlayer substrate bonding is strong).

**21013.** Blanchard, D. B.; Ross, R. C. Energy conservation in pigment milling via particle size instrumentation, *TAPPI* **64**, No. 8, 79-84 (Aug. 1981).

Key words: computers; energy; instrumentation; particle size; pigment.

To minimize energy consumption of the pigment milling step, a computer-controlled SEM/EDA instrumental system, designated as a Chemical Particulate Pattern Recognition System (CPPRS), is reviewed for monitoring particle size reduction. Discussed are the system fundamentals and an example of the system application for evaluation of milling energy consumption using a single- and multi-component pigment system.

**21014.** Fickett, F. R.; Goodrich, L. F. NBS superconductor standardization program, *Proc. 1980 Superconducting MHD Magnet Design Conf., Cambridge, MA, Mar. 26-27, 1980*, pp. 87-89 (Massachusetts Institute of Technology, Department of Energy, MHD Division, 170 Albany Street, Cambridge, MA 02139, Oct. 1981).

Key words: critical current; critical temperature; electrical property; low-temperature; standard; superconductor.

Modern practical superconductors are complex composites. The determination of their parameters is often difficult, and the results subject to various interpretations. The NBS program is attempting to create a number of consensus standards for the characterization of these materials. The major areas of concern this year are definitions of the parameters, development of standard critical current measurement techniques and a first look at problems related to critical temperature measurement. To this end, experimental work is being carried out both at NBS and by the wire manufacturers. Also, an ASTM committee has been formed and is actively engaged in the preparation of several draft standards. This paper describes our progress in each of the areas.

**21015.** Fickett, F. R. Electric and magnetic properties of CuSn and CuNi alloys at 4 K, *Cryogenics* **22**, 135-137 (Mar. 1982).

Key words: magnetic susceptibility; magnetoresistivity; superconductor.

Results of low-temperature resistivity, magnetoresistivity, and magnetic susceptibility measurements on CuSn and CuNi alloys of compositions commonly used in practical superconductors are presented and discussed.

**21016.** O'Sullivan, G.; Roberts, J. R.; Ott, W. R.; Bridges, J. M.; Pittman, T. L.; Ginter, M. Spectral-irradiance calibration of continuum emitted from rare-earth plasmas, *Opt. Lett.* **7**, No. 1, 31-33 (Jan. 1982).

Key words: absolute; calibration; continuum; irradiance; plasma; rare-earth.

The spectral irradiance of laser-produced plasmas of gadolinium and ytterbium have been determined in the 115-220-nm range for an incident 2.2-J, 30-nsec ruby-laser pulse. The effects of target geometry and variation of laser energy on the spectral irradiance were also studied. The potential of the source as a radiometric standard is discussed.

**21017.** Turrell, B. G.; Marshak, H. The determination of magnetic structures using low temperature nuclear orientation:  $^{166\text{m}}\text{Ho-Ho}$ , *Hyperfine Interact.* **11**, No. 3, 205-222 (Nov./Dec. 1981).

Key words: atomic magnetism; helical spin structure; holmium single crystal; low temperature; magnetic spin structure; nuclear magnetism; nuclear orientation;  $\gamma$  rays;  $^{166\text{m}}\text{Ho-Ho}$ .

It is demonstrated that the low temperature nuclear orientation technique can be used to determine the axes of quantization in a multiaxial ordered ensemble of nuclear spins. Expressions for the anisotropic  $\gamma$ -ray intensity from particular geometries are derived for the case in which each subsystem has its own axial symmetry. The determination of the atomic magnetic structure in antiferromagnets is discussed and the results of recent experiments on helically ordered  $^{166\text{m}}\text{Ho-Ho}$  are presented. In these experiments, the angular variation of the intensities of some of the more intense  $\gamma$ -rays were measured and compared to theory. A value of  $80.4 (1)^\circ$ , not including systematic errors, was obtained for the semi-cone angle of the helix formed by the atomic magnets.

**21018.** Furukawa, G. T.; Kaeser, R. S.; Marshak, H.; Pfeiffer, E. R.; Schooley, J. F.; Soulen, R. J.; Van Degrift, C. T. Fixed points and thermometric research below  $0^\circ\text{C}$  at the National Bureau of Standards, *Proc. Temperature Measurement in Industry and Science IMEKO TC 12 Symp., Karlov Vary, Czechoslovakia, Oct. 20-22, 1981*, pp. 32-38 (Czechoslovak Scientific and Technical Society, Dům techniky ČSVTS Praha, Gorkého nam. 23, Praha 1, Czechoslovakia, 1981).

Key words: low-temperature gases; noise thermometry; nuclear orientation thermometry; superconductors; temperature fixed points; thermodynamic temperature; thermometry; tunnel diode oscillators.

This paper presents a summary of current work at the U.S. National Bureau of Standards in the field of thermometry below  $0^\circ\text{C}$ . It describes temperature fixed point developments, including pressurized cells of Ar and other low-temperature gases as well as superconductors; a new low-temperature scale utilizing noise and nuclear orientation thermometry; studies of the 1976 0.5 K to 30 K Provisional Temperature Scale; and tunnel diode oscillators.

**21019.** Furukawa, G. T.; Burns, G. W.; Cutkosky, R. D.; Edsinger, R. E.; Evans, J. P.; Guildner, L. A.; Mangum, B. W. Temperature research above  $0^\circ\text{C}$  at the National Bureau of Standards, *Proc. Temperature Measurement in Industry and Science IMEKO TC 12 Symp., Karlov Vary, Czechoslovakia, Oct. 20-22, 1981*, pp. 39-47 (Czechoslovak Scientific and Technical Society, Dům techniky ČSVTS Praha, Gorkého nam. 23, Praha 1, Czechoslovakia, 1981).

Key words: automatic resistance bridges; gas thermometry; high-temperature platinum resistance thermometers; temperature fixed points; thermistor thermometers; thermocouple thermometers; thermodynamic temperatures; thermometry.

This paper presents a summary of current work at the U.S. National Bureau of Standards in the field of thermometry above  $0^\circ\text{C}$ . It describes temperature fixed point developments, including work on the triple points of water, Ga, Rb, In, and succinonitrile and on the freezing points of Sn, Zn, Al, and Cd; studies of microsil/nisil thermocouple thermometers; thermodynamic gas thermometry; the development of precision resistance thermometers for use up to  $1100^\circ\text{C}$ ; the development of new, automatic resistance bridges; and studies of thermistor and small platinum resistance thermometers.

**21020.** Bean, V. E. Transducers for very high pressures, *Proc. Second Int. Conf. High Pressure Engineering, University of Sussex, Brighton, July 8-10, 1975*, pp. 29-31 (Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW 1H 9JJ).

Key words: pressure; transducer.

Two new pressure transducers are currently being developed at NBS. In one the sensor is a parallel plate capacitor; in the other it is an ultrasonic delay line. Both have properties superior to the manganin gage and are being developed to be used as transfer standards in our calibration service.

**21021.** Carroll, J. J.; Melmed, A. J. Field ion microscopy of alpha uranium, *Surf. Sci.* **116**, 225-239 (1982).



Key words: hydride; hydrogen; microscopy; orthorhombic; surfaces; uranium.

Field ion micrographs of alpha uranium show atomic details of many orthorhombic crystal planes. Images of the (010) and (001) plane edges are examined and discussed in particular. Micrographs indicate that a surface hydride phase is formed readily under hydrogen imaging conditions. Some micrographs indicate possible hydride particle precipitation at a major crystal defect boundary. No evidence was found, however, of hydrogen/stress induced surface cracks. Procedures used to prepare alpha uranium for field ion microscopy are described.

**21022.** Bowman, C. D.; Carlson, A. D.; Wasson, O. A.; Schrack, R. A.; Behrens, J. W.; Johnson, R. G.; Duvall, K. C. White source use in a neutron standards laboratory, *Proc. IAEA Consultants' Meet. Neutron Source Properties, Kossuth Lajos University, Debrecen, Hungary, Mar. 17-21, 1980*, K. Okamoto, ed., pp. 119-134 (IAEA, Vienna International Centre, P.O. Box 100, A-1400, Vienna, Austria, June 1980).

Key words: absolute neutron measurement; neutron calibration; neutron source; neutron spectroscopy; neutron spectrum; neutron time-of-flight.

Methods are described for accurately characterizing the neutron beam from a white source in spectral shape, absolute intensity, and source brightness distribution. Measurements can be made over more than nine decades of energy from .01 to  $2 \times 10^7$  eV from a single source. Beams with easily modified spectrum and with total intensity (integrated over energy) of  $10^6$  n/cm<sup>2</sup>-sec can be obtained. Over most of the energy range these methods can be implemented with a modest electron linac facility operating in the 10-12 MeV range. Such a versatile facility is perhaps within the budgetary range of even a modest laboratory.

**21023.** Bartky, I. R.; Dick, S. J. The first North American time ball, *J. Hist. Astron.* xiii, 50-54 (1982).

Key words: Naval Observatory; navigation; observatory; time; time ball; time dissemination.

Accurate time dissemination for sea navigation and the general public was effected by time signals from astronomical observatories. The time signal devices, or time balls, began in 1829. The first North American time ball was installed on the dome of the U.S. Naval Observatory in Washington between 1 April 1845 and 1 September 1846. It was apparently the prototype for all American time balls erected by the U.S. Navy.

**21024.** Bartky, I. R.; Dick, S. J. The first time balls, *J. Hist. Astron.* xii, 155-164 (1981).

Key words: chronometers; Greenwich; Royal Observatory; time ball; time signals.

The use of visual time signals, or time balls, to rate chronometers is described. An analysis of the 19th British naval literature and material in the National Archives of the United States shows that the first time ball was at the Portsmouth, England base in 1829, rather than the Royal Observatory, Greenwich in 1833. Other early time balls and the observatories associated with them are discussed.

**21025.** Bell, B. A.; Petersons, O. ATE calibration by means of dynamic transport standards, *Proc. AUTOTESTCON 1981, Orlando Hyatt House, Orlando, FL, Oct. 19-21, 1981*, pp. 280-287 (Institute of Electrical and Electronics Engineers, 345 East 47 Street, New York, NY 10017, 1981).

Key words: automatic test equipment; calibration; calibration traceability; dynamic standards; transport standards.

The concept of dynamic transport standards for calibration of ATE in the field is discussed, with emphasis on ensuring the traceability of the calibrations to the basic physical standards as maintained by NBS. The technical details of the proposed transport standard for dc and low frequencies are outlined. The calibration support for this transport standard at NBS, at the standards laboratory, and self-checks in the field are discussed. Implementation of the calibration system for ATE based on the dynamic transport standards is discussed.

**21026.** Barnes, J. D. A computer-controlled apparatus for gas transmission measurements, *Proc. 40th Annu. Tech. Conf. and Exhibition of the Society of Plastics Engineers, San Francisco Hilton, San Francisco, CA, May 10-13, 1982*, pp. 19-21 (The Society of Plastics Engineers, 14 Fairfield Drive, Brookfield Center, CT 06805, 1982).

Key words: automation; computer control; gas transmission; permeation; permeation time-lag; SRM 1470; standard reference materials.

This paper describes a state-of-the-art facility for measuring the gas transmission characteristics of polymer films. Sensitive electronic manometers are used to monitor the rate at which gas passes through a film into an initially evacuated receiving volume. Three films are tested simultaneously. The minicomputer controls selection of the gas, setting the upstream pressure, opening and closing of all valves, and setting the experiment temperature. The experiment incorporates hard-wired logic to prevent damage from failures of films under test, failure of the gas controls, failure of the temperature controls, or computer failures. The facility can perform complex sequences of experiments in order to study such phenomena as partial immobilization, glass transition behavior, or activation energies. Human intervention is required only to change film specimens, to insert fresh data logging discs, or to initiate new sequences of experiments. Data reduction and analysis are performed on-line or over a network connection to a central computer. The recent recertification of SRM 1470 for permeances and time-lags of He, CO<sub>2</sub>, O<sub>2</sub>, and N<sub>2</sub> is described to illustrate the capabilities of the apparatus.

**21027.** Bell, B. A. Precision electronic test equipment calibration standards at NBS, *Proc. Automated Testing for Electronics Manufacturing and Test Instruments Conf., Pasadena Center, Pasadena, CA, Jan. 7-10, 1980*, pp. 138-168 (Benwill Publ. Corp., 1050 Commonwealth Avenue, Boston, MA 02215).

Key words: ac-dc difference; data conversion; dynamic response; linearity; metrology support; phase angle calibration; signal sampling; stability; waveform synthesis.

The application of sophisticated digital sampling and synthesis techniques to the implementation of precision electronic test, measurement, and diagnostic equipment imposes requirements for improved methods and standards to provide adequate metrology support. Several projects at NBS are described in this paper which deal with the investigation and development of means for evaluating the performance of certain classes of low frequency, audio, and lower RF instrumentation.

**21028.** Bell, B.; Souders, M.; Belanger, B.; Kamper, R. Challenges in achieving ATE traceability to NBS, *Proc. AUTOTESTCON 1979, Minneapolis, MN, Sept. 19-21, 1979*, pp. 233-238 (Institute of Electrical and Electronics Engineers, 345 East 47 Street, New York, NY 10017, Sept. 1979).

Key words: ATE; calibration; traceability.

For many years, government regulations and contractual agreements have required that measuring and test equipment be calibrated utilizing reference standards traceable to national standards. The advent of automatic test equipment (ATE) has introduced new complexities into the realization of traceability. This paper describes the problems inherent in achieving traceability for ATE as perceived by NBS, describes selected R&D activities at NBS that are providing some of the national reference standards and test techniques needed for supporting ATE calibration, and discusses a plan that is being proposed for providing more direct metrology support from NBS in this field.

**21029.** Coyne, J. J.; Caswell, R. S. Microdosimetric energy deposition spectra and their averages for bin-averaged and energy-distributed neutron spectra, *Proc. Seventh Symp. Microdosimetry, Oxford, UK, Sept. 8-12, 1980*, pp. 689-696 (Harwood Academic Publishers, P.O. Box 786 Cooper Station, New York, NY 10003).

Key words: bin-averaged cross sections; dose-averaged energy



loss; energy deposition spectra; energy distributed neutron spectra; frequency averaged energy loss; microdosimetric parameters.

Bin-averaged cross sections for hydrogen, carbon, nitrogen and oxygen, which were derived from the latest version of the nuclear data compilation, ENDF/B-V, have been used to calculate energy deposition spectra for a Rossi-type proportional counter filled with propane-based TE gas. The microdosimetric parameters  $\bar{y}_D$  and  $\bar{y}_T$  are given for contiguous bins extending from 2 MeV to 16 MeV. Energy deposition spectra have also been calculated for the 14.8 MeV neutron beam at TNO including the effects of the low energy neutrons in the beam. Microdosimetric spectra and their averages are given for the conditions: free in air, 10 cm depth in a water phantom and 20 cm depth in a water phantom.

**21030.** Coffey, S.; Deprit, A. Fast evaluation of Fourier series, *Astron. Astrophys.* **81**, 310-315 (1980).

Key words: celestial mechanics; Fourier series; lunar theory; satellite theory.

The multivariate Fourier series representing the orbit or the attitude of a celestial body are tabulated and stored in a machine-readable form as sequential data sets either on disk or on tape. It is shown here how such files can be converted by computer into data structures and coded automatically as program declarations ready for immediate insertion in subroutines designed to evaluate as quickly as possible multiple trigonometric series. The essential operation consists in replacing the file of angular multiples by a navigation table telling the evaluation subroutine how to evaluate the cosine and the sine of an integer combination of angles by applying the addition theorem of trigonometry automatically in a recursive manner.

As an example of such fully automatic conversion of a semianalytical theory into an ephemeris subroutine, Brown-Eckert's Improved Lunar Ephemeris ( $j=2$ ) is treated in detail. The result is a Fortran program delivering 100 independent positions of the moon in 4 s on a CDC 6600. With proper overlay organization, the program is short enough to fit in the core of a minicomputer.

**21031.** Aravind, P. K.; Rendell, R. W.; Metiu, H. A new geometry for field enhancement in surface-enhanced spectroscopy, *Chem. Phys. Lett.* **85**, No. 4, 396-403 (Jan. 22, 1982).

Key words: field enhancement; molecular fluorescence; surface geometry; surface spectroscopy,

We present calculations that indicate that for well-chosen materials a system consisting of a small sphere (diameter  $\leq 400$  Å) suspended above a planar surface, is a good laser intensity amplifier and an interesting candidate for surface-enhanced spectroscopy. Use of SiC and doped InSb extends the frequency range of surface-enhanced spectroscopy to the infrared ( $\approx 200$  to  $\approx 1100$   $\text{cm}^{-1}$ ).

**21032.** Chang, S. S. Specific heat of thermosetting resins: Study of phenolic resin by automated adiabatic calorimetry and differential scanning calorimetry, *Proc. Thermal Analysis in Polymer Characterization, The Eastern Analytical Symp., New York City, NY, Nov. 1980*, pp. 98-113 (Heyden & Sons, Inc., 247 South 41st Street, Philadelphia, PA 19104, 1981).

Key words: adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; specific heat; thermosetting polymers; varnishes.

Specific heat of a sample of resole-type phenolic resin was determined by a fully automated adiabatic calorimeter from 4 to 370 K. The temperature range of study was extended to 450 K by a differential scanning calorimeter on several samples of the phenolic resin. For a wide range of temperature, the specific heat of the phenolic resin can be represented by a simple proportionality to the temperature,  $c_p = 0.0042 \text{ T J g}^{-1} \text{ K}^{-1}$  or  $c_p = \text{T mcal g}^{-1} \text{ K}^{-1}$ , to within  $\pm 3\%$ . At above ambient temperatures the variation in the observed specific heat from differential scanning calorimetry may be attributable to the loss and absorption of moisture. A summary of specific heat of thermosetting resins, cross-linked polymers and varnishes are also given for the temperature region covering from 0.1 to 500 K.

**21033.** Clark, F. O.; Troland, T. H.; Lovas, F. J.; Schwartz, P. R. Detection of the 3.5 millimeter  $J=2-1$ ,  $v=2$  transition of circumstellar SiO, *Astrophys. J.* **244**, No. 2, L99-L102 (Mar. 1, 1981).

Key words: line formation; masers; stars, circumstellar shells.

The 3.5 mm  $J=2-1$ ,  $v=2$  transition of circumstellar SiO has been detected for the first time. This transition, from the Mira variable star R Cas, was about 50 times weaker than the corresponding 3.5 mm  $J=2-1$ ,  $v=1$  transition, both observed just prior to visual maximum. Two other SiO transitions from this star were also observed nearly simultaneously: these are the 7 mm  $J=1-0$ ,  $v=1$  and  $v=2$  lines. Six more SiO maser stars showed no evidence of 3.5 mm  $v=2$  emission during this observing period.

**21034.** Blumer, T. P.; Tenney, R. L. An automated formal specification technique for protocols, *Proc. Protocol Testing—Towards Proof?, Specification and Validation, National Physical Laboratory, Middlesex, United Kingdom, May 27-29, 1981*, 1, pp. 277-326 (National Physical Laboratory INWG/NPL, Teddington, Middlesex TW11 0LW, United Kingdom, May 1981).

Key words: automatic implementation techniques; communication protocols; computer network protocols; formal description techniques; protocol specification methods.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST) has initiated a program to develop computer network protocols standards as Federal Information Processing Standards (FIPS). This paper describes a formal method for specifying these computer communication protocols. The method, based on a finite automaton, is able to model quite diverse protocols and can be used as the basis for semi-automatic generation of protocol implementations.

**21035.** Soulen, R. J., Jr.; Rusby, R. L.; Van Vechten, D. A self-calibrating rhodium-iron resistive SQUID thermometer for the range below 0.5 K, *J. Low Temp. Phys.* **40**, Nos. 5/6, 553-569 (1980).

Key words: Josephson effect; Rh-Fe; SQUIDS; superconducting fixed points; thermometry.

We report on experiments with a prototype resistive SQUID device which show that it can serve both as a primary noise thermometer and as a secondary resistance thermometer in the range 0.01–0.52 K. The resistor in the circuit was made from an alloy of Rh with 0.5% Fe whose resistivity has an appreciable temperature dependence in this range. The high sensitivity of the SQUID allowed the resistance to be measured very accurately with negligible dissipation of heat. Since values of absolute temperature could be obtained by noise thermometry, the device was in effect a self-calibrating resistance thermometer. This combination of features is a rarity in thermometry in general, and may be unique in this temperature range. A version of this new thermometer has been fabricated and tested in the range 0.01–0.52 K. The results of experiments with this prototype are described, its limitations are examined, and ways of improving it are outlined.

**21036.** Cole, B. E.; Cooper, J. W.; Saloman, E. B. Field-induced autoionization in rare-gas absorption spectra near the ionization threshold, *Phys. Rev. Lett.* **45**, No. 11, 887-890 (Sept. 15, 1980).

Key words: autoionization; oscillator strength; photoionization; Stark effect.

The effect of electric fields of up to 22 kV/cm on the absorption cross sections of argon and krypton have been obtained near the ionization limit. In both gases the field-induced cross section below the limit is found to represent the predicted oscillator-strength distribution. In krypton, additional field-induced fine structure appears below the limit.

**21037.** Burt, P. E.; Fagg, L. W.; Crannell, H.; Sober, D. I.; Stapor, W.; O'Brien, J. T.; Maruyama, X. K.; Lightbody, J. W.; Lindgren, R. A. Electron scattering study of the 10.32 MeV transition in  $^{40}\text{Ca}$ , *Phys. Rev. C* **25**, No. 5, 2805-2809 (May 1982).

Key words: form factor; ground state transition width; inelastic electron scattering; magnetic dipole; Rosenbluth separation; 10.3 MeV transition;  $^{40}\text{Ca}$ .



Values of the form factor for the 10.32 MeV transition in  $^{40}\text{Ca}$  have been measured at six different low momentum transfers corresponding to incident electron energies between 31 and 65 MeV and scattering angles of 127.8° and 162.4°. Analysis of the data shows that the transition is transverse and  $M\ 1$ . Our data in conjunction with that of earlier workers yield a value of  $\Gamma_0(M\ 1) = 4.82 \pm 0.26\ \text{eV}$  for the ground state transition width. It is shown that in the low momentum transfer range covered in this work,  $q < 0.55\ \text{fm}^{-1}$ , this result is essentially model independent. Results for the transition at 9.86 MeV state are also discussed.

**21038.** Clark, H. E. An overview of United States activities for nonionizing electromagnetic radiation safety, *Proc. The Washington Impact: How It Affects Microwave Users, Sheraton-Washington Hotel, Washington, DC, Nov. 13-14, 1980*, pp. 34-60 (International Microwave Power Institute, 301 Maple Avenue West, Suite 520, Vienna, VA 22180).

Key words: bioeffects; dosimetry; electromagnetic; exposure; nonionizing; radiation; radiofrequency; regulation; safety; standards.

The speech provides a review of the overall U.S. Government Program of Nonionizing Electromagnetic Radiation (NER) Safety including: the goal and rationale of that program; the strategy for achieving it; identification of nearly all organizations (Federal or private) which have a role in assuring NER safety; a listing of all Federal and state exposure standards.

**21039.** Ichter, J. T.; Long, J. D.; Reeve, W. E.; Raufaste, N., ed. *The National Bureau of Standards: Research for defense construction, Mil. Eng. 74*, No. 480, 209-211 (The Society of American Military Engineers, 607 Prince Street, P.O. Box 180, Alexandria, VA 22313-0180, May-June 1982).

Key words: building materials; building technology; construction; Department of Defense; Tri-Services Committee.

The article reviews the National Bureau of Standards' Center for Building Technology (CBT) technical assistance provided to the Department of Defense's Tri-Services Committees. For over 40 years CBT has provided the Tri-Service Committees with a technical base to improve their building design and construction practices in a variety of areas: plumbing, structures, organic coatings, wind loads, environmental effects, energy conservation, and building economics. CBT findings have resulted in material and labor savings.

**21040.** Kurylo, M. J.; Cornett, K. D.; Murphy, J. L. The temperature dependence of the rate constant for the reaction of hydroxyl radicals with nitric acid, *J. Geophys. Res.* 87, No. C4, 3081-3085 (Apr. 20, 1982).

Key words: chemical kinetics; flash photolysis; hydroxyl radicals; nitric acid; rate constant; resonance fluorescence; stratospheric ozone.

The flash photolysis resonance fluorescence technique has been used to measure the rate constant for the reaction  $\text{OH} + \text{HONO}_2 \rightarrow \text{products}$  over the temperature range 225-443 K. The data below room temperature can be fit to the expression  $k_1 = (1.05 \pm 0.40) \times 10^{14} \exp[(759 \pm 100)/T]\ \text{cm}^3\ \text{molec}^{-1}\ \text{s}^{-1}$ . This equation, however, markedly underestimates the values of  $k_1$  above 300 K. An interpretation of the behavior is presented, and implications of these values for  $k_1$  on stratospheric reaction cycles are discussed.

**21041.** Currie, L. A.; Klouda, G. A.; Cooper, J. A. Mini-radiocarbon measurements, chemical selectivity, and the impact of man on environmental pollution and climate, *Radiocarbon* 22, No. 2, 349-362 (1980).

Key words: accelerator mass spectrometry; atmospheric pollution; carbonaceous gases and particles; carbon cycle; chemical selectivity; climate; low-level counting; radiocarbon.

Underlying principles and results are presented for our program to use isotopic and chemical methods to quantify anthropogenic and natural sources of carbonaceous pollutants. Radiocarbon data have been obtained with a specially-developed miniature low-level gas counting system which has permitted us to assay samples containing as little as 5 mg carbon. Measurements of carbonaceous particles,

using chemical selectivity and size fractionation to supplement the radiocarbon data, have revealed major impact from both fossil fuel and vegetative (contemporary) sources on urban aerosols. Residential wood-burning has been specifically identified as an important source of respirable particles. Current investigations are directed toward the carbonaceous gases and the application of the accelerator technique for the assay of radiocarbon in individual chemical fractions containing microgram quantities of carbon.

**21042.** Heldenbrand, J. L.; Ross, D. K.; Stein, R. G.; Tao, W. K. Y. Bridging the gap between component and energy performance criteria, *Light. Des. Appl.* 12, No. 1, 41-51 (Jan. 1982).

Key words: building energy performance; building subsystem energy criteria; energy conservation in lighting; general lighting; illumination energy; lighting energy; task lighting.

In order that building designers and builders may analyze and compare the energy (as contrasted with power or peak demand) implications of their design decisions, a method for performing the analysis and targeting the goals for the design energy consumption is needed. One approach to developing such a capability is to bridge the gap between component performance standards, such as ANSI/ASHRAE/IES 90 A, and design performance at the whole building level. A missing link is subsystem performance criteria. Development of energy performance criteria for the various energy-using subsystems would provide a common language, a goal-setting medium, information on the interactions among subsystems, and a flexible basis for conscious tradeoffs among subsystems and between the subsystems and the building envelope. This paper provides background on the need for performance-based criteria for the energy-using subsystems in buildings, describes a framework for one such approach, and illustrates its application to energy-conserving illumination subsystems for office buildings.

**21043.** Collins, B. Window management: An overview, *ASHRAE Trans.* 85, No. 2, 633-640 (1979).

Key words: control; daylight; energy balance; natural ventilation; psychological needs; view out; window; window management.

Window management has been defined as the selective alteration of the window's thermal and light transmission properties. In this paper the use of window management to alter window properties is discussed in terms of the need for energy conservation in buildings. Initially, a brief review of the psychological reaction to windows is given. Then thermal calculations of the energy balance at the window are given in terms of the use of daylight and window management. Finally, several studies on actual window management practices are reviewed. These include the use of natural ventilation, natural light, and venetian blinds. In conclusion, the need for further research into the factors that affect the use of window management is suggested, along with the urgent requirement to evaluate the window as a total system.

**21044.** Davis, R. W.; Moore, E. F. A numerical study of vortex shedding from rectangles, *J. Fluid Mech.* 116, 475-506 (1982).

Key words: computer simulation; external aerodynamics; fluid dynamics; mathematical modeling; numerical methods; unsteady flow; vortex shedding.

The purpose of this paper is to present numerical solutions for two-dimensional time-dependent flow about rectangles in infinite domains. The numerical method utilizes third-order upwind differencing for convection and a Leith type of temporal differencing. An attempted use of a lower-order scheme and its inadequacies are also described. The Reynolds-number regime investigated is from 100 to 2800. Other parameters that are varied are upstream velocity profile, angle of attack, and rectangle dimensions. The initiation and subsequent development of the vortex-shedding phenomenon is investigated. Passive marker particles provide an exceptional visualization of the evolution of the vortices both during and after they are shed. The properties of these vortices are found to be strongly dependent on Reynolds number, as are lift, drag, and Strouhal number. Computed Strouhal numbers compare well with those obtained from a wind-tunnel test for Reynolds numbers below 1000.

**21045.** Demas, J. N.; Bowman, W. D.; Zalewski, E. F.; Velapoldi, R.



A. Determination of the quantum yield of the ferrioxalate actinometer with electrically calibrated radiometers, *J. Phys. Chem.* **85**, No. 19, 2766-2771 (Sept. 17, 1981).

Key words: absolute calibration; absolute quantum yield; actinometry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; transfer standard.

Amplitude-stabilized laser sources and electrically calibrated radiometers were used for the absolute calibration of the quantum yield  $\phi_{Fe^{2+}}$  of the ferrioxalate actinometer at three laser lines. Improved accuracy and precision were obtained compared to previously reported values. The values of  $\phi_{Fe^{2+}}$  were found to be  $0.845 \pm 0.011$  at 457.9 nm (0.15 M ferrioxalate concentration),  $1.188 \pm 0.012$  at 406.7 nm (0.006 M) and  $1.283 \pm 0.023$  at 363.8 nm (0.006 M). The total uncertainties are at the 99.5% confidence limits and include components for the random measurement error and the estimated bias of the measurement. The  $\phi_{Fe^{2+}}$  values at 368.8 and 406.7 nm agree reasonably well with previously reported values; however, the value at 457.9 nm is  $\sim 13\%$  lower than an interpolation between previously reported values. The  $\phi_{Fe^{2+}}$  value at 457.9 nm was independent of the order of reagent addition, the presence of oxygen, flux density changes, and concentration of  $Fe^{2+}$  formed. Possible causes for the discrepancy at 457.9 nm are discussed. The ferrioxalate actinometer is recommended as a transfer standard for the calibration of laser power meters.

**21046.** Bell, R. E.; Finkenthal, M.; Moos, H. W. Time-resolving extreme ultraviolet spectrograph for fusion diagnostics, *Rev. Sci. Instrum.* **52**, No. 12, 1806-1813 (Dec. 1981).

Key words: plasma diagnostics; ultraviolet detector; ultraviolet spectrograph.

A time-resolving spectrograph for the simultaneous measurement of emissions at extreme ultraviolet wavelengths (300–2200 Å) is described. The spectrograph is a 400-mm normal incidence f/30 system with seven gratings. Together two of the gratings cover the entire wavelength range at low resolution. The other five gratings have higher dispersion and cover adjacent intervals of the spectrum. The spectral resolution varies between 0.7–4 Å. The detector consists of a windowless microchannel plate/phosphor screen image intensifier, coupled by fiber optics to a 1024-element self-scanning integrated photodiode array. The output from the array is digitized and stored by a small desktop computer which has sufficient memory to record up to 80 spectra during a single plasma discharge.

**21047.** Borresen, B. A. Thermal room models for control analysis, (Proc. ASHRAE 1981 Annu. Meet., Cincinnati, OH, June 28-July 1, 1981), *ASHRAE Trans.* **87**, Pt. 2, 251-261 (1981).

Key words: air conditioning; air distribution; building systems; computer; control; modeling; office building; thermal response; ventilation.

The analysis of a dynamic control loop often requires the use of a room model. This paper discusses four simplified dynamic room models which in different ways take into account the thermal interaction between room air and surrounding walls. The room air is assumed to be fully mixed.

It is shown that the choice of the simplification level employed depends on how closely the long-term responses and steady-state values are to fit the actual room response. For modeling short-term dynamic responses, a simple time constant corresponding to the air change rate of the room is usually adequate and will lead to choosing conservative control parameters.

An experimental procedure for determining typical parameter values is discussed.

**21048.** Borresen, B. A. HVAC control process simulation, (Proc. ASHRAE 1981 Annu. Meet., Cincinnati, OH, June 28-July 1, 1981), *ASHRAE Trans.* **87**, Pt. 2, 871-882 (1981).

Key words: air conditioning; building systems; computer; control; heat exchanger; modeling; monitoring; research; steam; thermal response; valve.

The modeling and simulation of HVAC systems and their controls

is necessary for properly understanding the dynamic performance of heating and cooling processes in buildings. In carrying out such analyses, it is useful to distinguish between closed-loop control and steering or open-loop control. In addition, HVAC systems and controls are characterized by large working ranges. It is normal to have systems operating at low loads for a large portion of a heating or cooling season and to have to contend with large non-linearities.

This paper discusses the simulation of closed-loop control systems and develops a methodology for modeling nonlinear systems. The simulation is primarily characterized by a "chaining process" and a "transition process." In the chaining process, all the elements in the system are coupled together and all nonlinearities are accounted for. During the transition process, all the elements are decoupled, the inputs are held constant, and the outputs are calculated for one step in the future. The simulation is, therefore, not depending on solving a high number of simultaneous equations. This is especially advantageous when dealing with non-linear systems. The primary structure of the simulation model is built up around time constants, transport delays and non-linear elements.

The usefulness of this simulation methodology is illustrated by presenting some results obtained by modeling the performance of a steam-heated air coil controlled by an adaptive control algorithm. This example includes the steam valve, steam trap, and condensate build-up in the coil, and is extremely nonlinear.

**21049.** Peterson, R. L. Mathematical modelling of the impedance of a Josephson junction noise thermometer, *J. Appl. Phys.* **52**, No. 12, 7321-7326 (Dec. 1981).

Key words: Josephson junctions; noise thermometers; nonlinear differential equation; superconductivity.

Recent experimental work on noise thermometers consisting of a resistively shunted superconducting loop containing a Josephson junction (a resistive SQUID) has shown some novel behavior of the SQUID dc impedance as a function of rf power. We present a mathematical analysis of the intrinsic behavior of a resistive SQUID in the limit of negligible noise and negligible feedback to the rf circuit. A nonlinear, first-order differential equation is thought to be a reasonable descriptor of this system. Because the radio frequency driving the SQUID is much larger than the Josephson frequency, we are able to obtain a pair of equations in which no rf oscillating terms appear, and which are amenable to numerical solution. The dc impedance calculated from these equations has several, but not all, of the experimentally observed features.

**21050.** Donvito, P. A. Gasohol: The real issue is B.T.U.'s, Article in *The New York Times*, p. 4 (July 13, 1980).

Key words: energy; energy balance; energy economics; ethanol.

A distinction is drawn between technical efficiency and economic efficiency within the context of producing ethanol for fuel. There is a question as to whether the energy used for ethanol production exceeds the energy produced. In this paper, it is maintained that the input and output ratio is not relevant, if the value of the energy output exceeds the value of the energy plus the other necessities for ethanol production.

**21051.** Dragoo, A. L.; Domingues, L. P. Preparation of high-density ceria-yttria ceramics, *J. Am. Ceram. Soc.* **65**, No. 5, 253-259 (May 1982).

Key words: carbonates, cerium-yttrium, coprecipitation of; ceramics, ceria-yttria, high-density; ceramics, ceria-yttria, hot-pressing of; cerium dioxide, yttrium-doped; cerium-yttrium oxide ceramic; cerium-yttrium oxide powders; homogeneous solution, precipitation from; lattice constant of yttrium-doped cerium dioxide.

Fine Ce-Y oxide powders were prepared by coprecipitation of the carbonate, followed by calcination at 620°C. Hydrolysis of trichloroacetic acid was used to precipitate most of the material from a homogeneous solution; addition of ammonium bicarbonate and ripening of the precipitate were used to increase the yield to 68 to 70%. The precipitate apparently consisted of more than one phase and had an overall composition which suggested that it was a possible mixture of hydrated carbonate, hydroxycarbonate, and hydroxide. The calcined oxide powder was used to prepare a yttria-doped ceria ceramic by hot-pressing. The ceramic had the fluorite structure phase



with a lattice constant of 0.541088 nm and a composition of  $\text{Ce}_{0.914}\text{Y}_{0.086}\text{O}_{1.957}$ . The bulk density of the material was 6.96 g/cm<sup>3</sup>, or 99.4% of theoretical density. The ceramic had equiaxed grains, with an average dimension of 1 to 4  $\mu\text{m}$  and with residual porosity mainly along the grain boundaries. Ac impedance properties of the chemically prepared oxide are compared with those of mechanically mixed and fired Y-doped  $\text{CeO}_2$ .

- 21052.** Bowen, R. L.; Rapson, J. E.; Dickson, G. Hardening shrinkage and hygroscopic expansion of composite resins, *J. Dent. Res.* **61**, No. 5, 654-658 (May 1982).

Key words: absorption; composite resins; expansion; hardening shrinkage; hygroscopic expansion; polymerization; water sorption.

Polymerization shrinkages of various restorative resins were measured. The specimens stored in water expanded, but most did not recover sufficiently to countervail the losses from polymerization.

- 21053.** Hughey, L. R.; Schaefer, A. R. Reduced absolute uncertainty in the irradiance of SURF-II and instrumentation for measuring linearity of X-ray, XUV and UV detectors, *Nucl. Instrum. Methods* **195**, 367-370 (1982).

Key words: calibration; electrons; instrumentation; photon detectors; SURF-II.

The uncertainty in the number of stored electrons was the major component of the absolute uncertainty (except at the shortest wavelengths) in the photon flux from SURF-II. A highly linear silicon diode with spectral sensitivity from 200 nm to 1150 nm, and a quartz window and lens which collect 70 mrad of radiation are used as a beam current monitor. The combination of the diode (selected ones known to be linear to within 0.2% over nine decades), the wide band width and collection angle (providing a sensitivity of 0.2 pA per electron) is the foundation for the improvement in measurement accuracy. The high sensitivity is used to detect incremental changes in detector output as the number of stored electrons is reduced one by one for stored currents from  $10^4$  electrons to zero. The diode linearity is used to scale the current up to  $5 \times 10^9$  electrons (45 mA). The use of these linear diodes (with *in situ* calibration), at SURF and other storage rings, to determine the linearity of photon detectors which are sensitive to any radiation emitted by that storage ring will be discussed.

- 21054.** Lettieri, T. R.; Jenkins, W. D.; Swyt, D. A. A laser-based resonant scattering system for size measurement of individual droplets and microspheres, *Proc. Laser 1981 Opto-Elektronik, Munich, West Germany, June 1-4, 1981*, pp. 171-175 (Springer-Verlag, Berlin, 1982).

Key words: light scattering; liquid droplets; microspheres; Mie theory; optical levitation; particle sizing; polarization ratio; radiation pressure; resonances.

A laser-based system for high-resolution sizing of individual microspheres is described. By making use of the sharp resonances which appear in the elastic scattering cross-sections of optically levitated particles, changes in diameter as small as 1 part in  $10^4$  can be detected. Experimental and theoretical results are given for two light scattering parameters, namely, polarization ratio and radiation pressure. The implications of these results for high-resolution sizing is discussed for three different cases involving evaporating liquid droplets and solid microspheres.

- 21055.** Pruitt, J. S.; Loevinger, R. The photon-fluence scaling theorem for Compton-scattered radiation, *Med. Phys.* **9**, No. 2, 176-179 (Apr. 1982).

Key words: cobalt-60 gamma rays; Compton scatter; fluence scaling; graphite phantom; ionization chamber; water phantom.

This paper concerns a method of scaling photon fluence from one scattering material to another when the photon energies are such that the dominant mode of interaction is Compton scattering. The theorem establishes a one-to-one correspondence between points in the two scattering media where the spectra of primary and scattered photons have the same distribution in energy and angle, and where the fluence ratio equals the square of the electron density ratio. Experimental

tests were made with cobalt-60 gamma radiation using ionization-chamber measurements in graphite, acrylic plastic, polystyrene, and water phantoms. The experimental results are consistent with the equality of photon spectral shapes and angular distributions at corresponding points. The fluence ratios may differ by a few percent from the predicted values, depending on distance from the source.

- 21056.** Ederer, D. L. Photoionization, Article in *Encycl. Phys.*, pp. 748-749 (Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA, 1976).

Key words: atoms; cross section; electron-ion pairs; electron shells; molecules; photoionization.

Photoionization is a process where a photon of frequency  $\nu$  and energy  $h\nu$  interacts with an atom or molecule to produce ion-electron pair. The probability of ionization is represented by the photoionization cross sections given in terms of an area. At the ionization threshold, the cross section typically has a value of  $10^{-17}$  cm<sup>2</sup>.

- 21057.** Detrich, J.; Weiss, A. W. Alkali-metal-atom doublet anomalies and the relation between relativistic and nonrelativistic theories, *Phys. Rev. A* **25**, No. 2, 1203-1205 (Feb. 1982).

Key words: doublet inversions; relativistic effects; spectroscopy.

The single-configuration Dirac-Fock treatment of doublet splittings in alkali-like spectra is examined, and it is shown that the nonrelativistic limit is not the nonrelativistic Hartree-Fock, but a multiconfiguration, core-polarization approximation. The latter is the mechanism which has conventionally been invoked to account for the anomalous doublet splittings of nonpenetrating states in alkali-like atomic systems. Both approaches should thus be capable of representing the doublet anomalies.

- 21058.** Celotta, R. J.; Huebner, R. H. Electron impact spectroscopy: An overview of the low-energy aspects, Chapter 2 in *Electron Spectroscopy: Theory, Techniques and Applications*, **3**, 41-125 (Academic Press Inc., New York, NY, 1979).

Key words: electron energy loss; electron impact excitation; electron spectroscopy; generalized oscillator strength.

An overview is presented of the area of low impact energy ( $< 1000$  eV) electron scattering from free atoms and molecules. Topics covered include electron energy-loss spectra, excitation function measurements, ionization measurements, and the determination of generalized oscillator strengths from electron impact data. Recent multiparameter experiments are discussed as well as the application of electron spectroscopy to quantitative analysis.

- 21059.** Peterlin, A. Dynamic viscosity of polymer solutions, *Colloid Polym. Sci.* **260**, No. 3, 278-293 (June 1982).

Key words: Aroclor; dynamic intrinsic viscosity; internal viscosity; necklace model; polystyrene.

The dynamic viscosity of different long chain polymers in Aroclor permits an easy extrapolation to zero concentration only in the limiting cases of Newtonian, i.e., constant viscosity at low and high frequency, respectively. The first intrinsic viscosity  $[\eta]_0$  is independent of any concept of the internal viscosity. In the case of polystyrene it is proportional to  $M^{0.65}$  which shows that Aroclor is a good solvent for this polymer. The second intrinsic viscosity  $[\eta]_\infty$  turns out to be independent of  $M$ . It is best reproduced by the model where the internal viscosity resists only the deformation rate of the single link. The displacement rate of more distant beads is affected by the internal viscosity only in the case that it involves the deformation rate of the links. The angles between successive links may be changed at any rate.

In the intermediate range of frequencies the extrapolation of the observed dynamic viscosity to the intrinsic value was never made. The experimental data are so much affected by the concentration, i.e., by the interaction of adjacent molecules, that no conclusion may be derived from them about the properties of the isolated macromolecule. A master curve independent of  $M$  and  $c$  is obtained by plotting of  $(G'' - \omega\eta_\infty)K/c$  over  $\omega\tau_1$ . This means that the deformation mode in the whole molecular weight and concentration range investigated is the same. But this mode is different from that of the independent macromolecule in infinite dilution. The master curve



may be described by the excess intrinsic viscosity of the Rouse model with the internal viscosity acting either between the beads on the same link only or between any distinct beads. As a consequence of the concentration effects, however, no conclusions about the properties of the single molecule can be derived from such an agreement.

**21060.** Appleman, B. R.; Campbell, P. G. Salt spray testing for short term evaluation of coatings. Part I: Reaction of coatings in salt spray, *J. Coatings Technol.* **54**, No. 686, 17-25 (Mar. 1982).

Key words: coatings; salt-spray test; short-term tests.

Various aspects of short-term testing of coatings for steel are examined, with particular emphasis on the salt spray test. The salt spray test is the most widely used and the most widely criticized of the accelerated test methods. The salt spray test continuously exposes a coating to a neutral salt solution at an elevated temperature. The test excludes ultraviolet light and atmospheric pollutants. The chemical and physical consequences of this artificial environment are reviewed. The coating's ability to protect against corrosion is examined in light of the principal mechanisms (i.e., barrier, inhibitive, sacrificial). In addition, the observed and expected effects of salt spray are discussed for specific coating binder types including oil and alkyd systems, vinyls and other thermoplastic polymers, catalyzed epoxies, latexes, and zinc-rich primers.

**21061.** Crawford, M. L. Options to open-field and shielded enclosure electromagnetic compatibility measurements, *Proc. 4th Symp. and Technical Exhibition Electromagnetic Compatibility, Zurich, Switzerland, Mar. 10-12, 1981*, pp. 383-388 (Federal Institute of Technology, Zurich, Switzerland, 1981).

Key words: buried electromagnetic enclosures; electromagnetic compatibility measurements (EMC); low-Q chambers; reverberation chambers; transverse electromagnetic cells.

This paper discusses optional measurement techniques that are being investigated as potential alternatives to using open-field sites and conventional shielded enclosures for performing EMC measurements. Techniques discussed include: 1) low-Q underground or buried test chambers, 2) transverse electromagnetic (TEM) transmission line cells, and 3) reverberating or mode tuned/stirred enclosures.

**21062.** Crawford, M. L.; Workman, J. L. Predicting free-space radiated emissions from electronic equipment using TEM cell and open-field site measurements, (Proc. 1980 Int. Symp. Electromagnetic Compatibility, Baltimore, MD, Oct. 7-9, 1980), *IEEE Cat. No. 80CH1538-8EMC*, pp. 80-85 (Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017, 1980).

Key words: electromagnetic radiated emissions measurements; open-field site; transverse electromagnetic cells.

This paper gives an analysis for determining equivalent free-space (reference environment) radiated emissions from electronic equipment using transverse electromagnetic (TEM) cells and open-field site measurements. Test results and an estimate of the accuracy of emission measurements made using a "control standard emitter" in TEM cells and on an open-field site are given and compared with the standard emitter's theoretically predicted free-space emissions.

**21063.** Lhota, E.; Manninen, M. T.; Pekola, J. P.; Soinne, A. T.; Soulen, R. J., Jr. Intercomparison of NBS and Helsinki temperature scales in the millikelvin region, *Physica* **107B**, 337-338 (1981).

Key words: beryllium; fixed points; liquid  $^3\text{He}$ ; superconductivity; temperature; transition temperature; tungsten.

The Helsinki temperature scale, based on platinum NMR, is compared with the NBS noise and nuclear orientation temperature scale by means of three fixed points: the  $^3\text{He}$  superfluid transition temperature at zero pressure ( $T_c$ ) and the superconductive transition temperatures of samples of W and Be. The value for  $T_c$  on the NBS scale is found to be 1.025 mK, in close agreement with the Helsinki value of 1.04 mK. This result supports the liquid  $^3\text{He}$  heat capacity data measured earlier at Helsinki.

**21064.** Van Degriest, C. T. Pulsing of tunnel diode LC oscillator

sensors, *Physica* **108B**, 1361-1362 (1981).

Key words: LC oscillator; oscillator sensor; pressure; pulsed oscillator; pulsed sensor; temperature; tunnel diode; tunnel diode oscillator.

It is demonstrated that tunnel diode LC oscillator sensors may be turned on and measured within 33 ms while still retaining a frequency precision of 0.01 ppm. This allows their use in very low temperature applications where power dissipation is a serious problem or in magnetic resonance applications where a pulsed rf susceptometer might be desirable. Furthermore, this makes practical the rapid scanning of a large array of sensors with one dc power source and measurement system.

**21065.** DiMarzio, E. A.; Guttman, C. M.; Hoffman, J. D. Study of amorphous-crystal interfaces in polymers using the wicket model: Estimates of bounds on degree of adjacent reentry, *Polymer* **21**, 1379-1384 (Dec. 1980).

Key words: adjacent reentry; density at interface; distribution of polymer loops; interfacial thickness; polymer; polymer interfaces.

An attempt to ascertain the structure of the crystal-amorphous interface in polycrystalline polymers of lamellar morphology is made by discussion of an idealization of loops called wickets. Equations which arise from the constraints of density at the interface are obtained that relate the various kinds of wickets to their lengths and to interface thickness. A measure of the degree of adjacent reentry is defined and bounds on the extent of adjacent reentry are obtained. It is found that the larger the assumed value of average loop size the larger the amount of adjacent reentry. Infinite average loop size results in complete adjacent reentry.

**21066.** DiMarzio, E. A.; Guttman, C. M.; Hoffman, J. D. Calculation of lamellar thickness in a diblock copolymer, one of whose components is crystalline, *Macromolecules* **13**, No. 5, 1194-1198 (Sept.-Oct. 1980).

Key words: block copolymers; chain folding in polymers; copolymer; phase transition in polymers; polymer crystals.

We treat a diblock copolymer of lamellar morphology where one of the blocks is amorphous and one is crystalline (amphiphilic copolymer). The proposed models allow for the stretching of polymer chains, the change in packing entropy arising from changes in orientation of bonds, and the space-filling properties of the chains. Formulas are given for the thickness of the amorphous and crystalline lamellae,  $l_a$  and  $l_c$ , as functions of the lengths of the blocks,  $r_a$  and  $r_c$ , the surface and fold free energies,  $\sigma_s$  and  $\sigma_p$ , the temperature  $T$ , the amount of solvent in the amorphous phase  $v_0 = 1 - v_p$ , and the densities  $\rho_a$  and  $\rho_c$  ( $\rho_a = v_p \rho_p$ ). We have  $l_a = r_a^{2/3} (\sigma_s + \sigma_p \rho_c)^{1/3} / (3kT\rho_a)^{1/3}$  and  $l_c = r_c \rho_c^{2/3} (\sigma_s + \sigma_p \rho_c)^{1/3} / \rho_c r_a^{1/3} (3kT)^{1/3}$ .

**21067.** DiMarzio, E. A. Equilibrium theory of glasses, *Ann. N.Y. Acad. Sci.* **371**, 1-20 (Oct. 26, 1981).

Key words: equilibrium theory; glass formation; glass transition; polymer glasses.

It is shown that certain kinds of molecules cannot even in principle pack together in regular array (crystallize). This means that their low temperatures,  $T$  (high pressure,  $P$ ) equilibrium state is an amorphous (glassy) state. The equilibrium amorphous state properties at low  $T$  as well as at high  $T$  were obtained using a lattice model for a system composed of asymmetric molecules. The effects of both intra and inter molecular energetics were (crudely) incorporated. A second-order transition in the Ehrenfest sense was predicted which is due to the configurational entropy (packing entropy)  $S_c$  approaching zero at finite  $T$ ,  $P$  as we lower the temperature. The variation of glass temperature was successfully predicted as a function of molecular weight, diluent concentration (plasticizer), copolymer composition, and of degree of cross-linking and stretch ratio in a rubber. The PVT and EVT equations of state are also successfully (semiquantitatively) modeled. In short, assemblies of molecules that form glasses do have equilibrium properties, and we have calculated what they are. Kauzmann's paradox is resolved.

**21068.** Dornhaus, R.; Benner, R. E.; Chang, R. K.; Chabay, I. Surface plasmon contribution to SERS, *Surf. Sci.* **101**, 367-373 (1980).



Key words: adsorbed monolayers; Raman spectra of monolayers; surface enhanced Raman spectroscopy (SERS); surface plasmons; surface roughness.

The contribution of surface plasmon excitation to SERS has been experimentally investigated with molecules adsorbed on 5 and 57 nm evaporated Ag films coated on a hemicylindrical prism which enabled direct excitation of surface plasmons in the Kretschmann configuration. Surface plasmon excitation increases SERS intensities by at least  $10\times$  while metal islands of Ag give much larger SERS intensities.

21069. Larsen, P. K.; Van Bers, W. A. M.; Bizau, J. M.; Wuilleumier, F.; Krummacher, S.; Schmidt, V.; Ederer, D. Design and performance of a toroidal grazing incidence monochromator for the 20–200 eV photon energy range, *Nucl. Instrum. Methods* 195, 245–250 (1982).

Key words: grazing incidence; monochromator efficiency; synchrotron radiation; toroidal grating; ultrahigh vacuum; vacuum ultraviolet.

A new monochromator using holographically ruled toroidal gratings, has been built for the A61 beam line at the ACO storage ring in Orsay. The performance of the monochromator was evaluated from photoelectron measurements on photoionized rare gases (PAX technique). Measurements of photon flux, efficiency in the various orders, and resolution are summarized.

21070. Ayres, T. R.; Linsky, J. L.; Basri, G. S.; Landsman, W.; Henry, R. C.; Moos, H. W.; Stencel, R. E. Outer atmospheres of cool stars. XI. High-dispersion IUE spectra of five late-type dwarfs and giants, *Astrophys. J.* 256, No. 2, 550–558 (May 15, 1982).

Key words: stars, atmospheres; stars, chromospheres; stars, late-type; ultraviolet, spectra.

We present high-dispersion, far-ultraviolet (1150–2000 Å) spectra of five late-type dwarfs and giants obtained with the *International Ultraviolet Explorer*. The chromospheric ( $T \lesssim 10^4$  K) emission lines in the giants tend to be about twice as broad as the corresponding features of the dwarf star spectra, suggesting a width-luminosity relation similar to the Wilson-Bappu effect for Ca II H and K. The Si III  $\lambda 1892$  and C III  $\lambda 1909$  intercombination lines formed in hotter layers ( $T \approx 5 \times 10^4$  K) also broaden by a factor of 2 from the main-sequence stars to the evolved stars, and the permitted resonance doublets of C II ( $3 \times 10^4$  K), Si IV ( $6 \times 10^4$  K), and C IV ( $10^5$  K) are as much as a factor of 4 broader in the giants than in the dwarfs. However, we find no evidence for asymmetric or shifted emission profiles that might indicate the presence of warm ( $T \lesssim 10^5$  K) stellar winds. We conclude that broad C IV profiles, in particular, are typical of active chromosphere giant stars and are unlikely to be a unique signature of an extended, expanding warm wind. Since the resonance lines tend to be wider than the intersystem lines formed at similar temperatures in the chromosphere and in hotter layers, we conclude that opacity must be an important broadening enhancement mechanism in active chromosphere giant stars. Nevertheless, the intercombination line widths do indicate a general increase in the outer atmosphere Doppler motions from the dwarfs to the giants.

Application of the density sensitive line ratio C III  $\lambda 1909$ /Si III  $\lambda 1892$  suggests that the outer atmosphere pressures ( $T \approx 5 \times 10^4$  K) are similar in the active chromosphere subgiant  $\lambda$  And and the quiet chromosphere dwarfs,  $\alpha$  Cen A and B. However, the pressures derived for the Capella secondary and  $\beta$  Dra are factors of 3 or more lower than the dwarfs, suggesting geometrically extended, low-density outer atmosphere structures qualitatively different from the high-pressure, compact structures typical of solar magnetic active regions.

Finally, we have isolated the He II  $\lambda 1640$  emission component from contaminant blends, and we find that the line strength is well correlated with soft X-ray fluxes of the sample stars, as predicted by photoionization-recombination models of the He II Ba formation.

21071. Rogers, W. T.; Stefani, G.; Camilloni, R.; Dunn, G. H.; Msezane, A. Z.; Henry, R. J. W. Electron-impact ionization of  $\text{Zn}^+$  and  $\text{Ga}^+$ , *Phys. Rev. A* 25, No. 2, 737–748 (Feb. 1982).

Key words: crossed beams; electron impact; excitation-autoionization;  $\text{Ga}^+$ ; ionization;  $\text{Zn}^+$ .

Absolute cross sections for electron-impact ionization of  $\text{Zn}^+$  and  $\text{Ga}^+$  have been measured from below threshold to 2 keV with the use of the crossed-charged-beams technique. Excitation autoionization was shown to be of major importance in both ions for the region between 1 and 2 times threshold, leading to enhancement of the cross sections by factors of up to  $\sim 2.5$ . Discrepancies between experiment and the well-known semiempirical formula of Lotz were up to 70%, but reduction of Lotz's  $a_{3d}$  coefficient by a factor of 2 leads to satisfactory agreement at high energies. Comparison is also made with scaled-Born-approximation calculations.

21072. Rogers, W. T.; Dunn, G. H.; Olsen, J. O.; Reading, M.; Stefani, G. Absolute emission cross sections for electron-impact excitation of  $\text{Zn}^+(4p\ ^2P)$  and  $(5s\ ^2S)$  terms. I, *Phys. Rev. A* 25, No. 2, 681–691 (Feb. 1982).

Key words: crossed beams; cross sections; electron impact excitation; lifetime; polarization;  $\text{Zn}^+$ .

Absolute emission cross sections for electron-impact excitation of the  $3d^{10}4p\ ^2P$  and of  $\text{Zn}^+$  have been measured from below threshold to about 790 eV ( $^2P$ ) and 388 eV ( $^2S$ ) using the crossed-charged-beams technique. Both transitions have the abrupt onset at threshold characteristic of positive-ion excitation. The  $^2P$  cross section shows considerable structure in the interval from threshold to near 20 eV, above which it falls off smoothly. Agreement with five-state close-coupling theory is excellent below 100 eV when cascading is included in the theory. Above 100 eV, the data lie above the theory. The peak value of the  $^2P$  cross section is  $9.4 \times 10^{-16}$  cm<sup>2</sup> essentially at threshold, while the peak value of the  $^2S$  cross section is about  $0.47 \times 10^{-16}$  cm<sup>2</sup>. The net linear polarization of the  $3d^{10}4p\ ^2P$  emission was measured (unresolved from the transition), and these data were used to correct the cross-section data for anisotropy of the emitted light. The effective lifetime of the  $3d^9 4s^2 D_{3/2}$  level was measured by observing exponential decay of the 589.6-nm photons resulting from its decay.

21073. Crandall, D. H.; Phaneuf, R. A.; Falk, R. A.; Belić, D. S.; Dunn, G. H. Absolute cross-section measurements for electron-impact ionization of Na-like ions— $\text{Mg}^+$ ,  $\text{Al}^{2+}$ , and  $\text{Si}^{3+}$ , *Phys. Rev. A* 25, No. 1, 143–153 (Jan. 1982).

Key words:  $\text{Al}^{2+}$ , crossed beams; cross sections; electron impact; excitation-autoionization; ionization;  $\text{Mg}^+$ ; Na iso-sequence;  $\text{Si}^{3+}$ .

Measured cross sections for single ionization of  $\text{Mg}^+$ ,  $\text{Al}^{2+}$ , and  $\text{Si}^{3+}$  by electron impact are reported. Crossed beams of electrons and ions have been employed to study the absolute cross sections as a function of collision energy in detail. Near threshold the cross sections for  $\text{Mg}^+$  and  $\text{Al}^{2+}$  are roughly 70% of the predicted direct-ionization cross sections, while  $\text{Si}^{3+}$  is in reasonable agreement with the predictions. Contributions to the total cross section by indirect processes, principally inner-shell-excitation autoionization, are specifically identified in each case and compared with theoretical results. These comparisons demonstrate specific failures of the predictions which rely on addition of excitation cross sections to the direct-ionization cross section.

21074. Norcross, D. W. Application of the adiabatic-nuclei approximation to energy-loss cross sections for collisions with molecules, *Phys. Rev. A* 25, No. 2, 764–772 (Feb. 1982).

Key words: adiabatic nuclei approximation; molecular collisions; stopping cross sections.

A general expression is derived for the energy-loss, or stopping, cross section for particles incident on linear or symmetric-top molecules, within the context of the adiabatic-nuclei approximation for vibration and rotation, or only rotation. The derivation is an alternative to that of Shimamura, and confirms his proof that the cross section is, when summed over all final rotor states, independent of the initial rotor state. It involves a sum rule for Clebsch-Gordan coefficients that, if not newly derived here, is certainly unfamiliar. The expression relating body-frame (fixed-nuclei) and laboratory-frame cross sections for linear and symmetric-top molecules is generalized to the asymmetric-top molecule, and it is shown that for this case the cross section for transitions between any rotational states can be written as a simple linear combination of the cross sections for



the ground rotational state only in special circumstances. Application of Shimamura's theorem to this case leads to a general expression, applicable to all three classes of molecules, that is ideally suited to use with the results of standard fixed-nuclei scattering calculations. Applications near threshold and/or for polar molecules are discussed and illustrated for electron collisions with CO.

- 21075.** Haan, S. L.; Geltman, S. Time development of resonant multiphoton ionisation of sodium, *J. Phys. B: At. Mol. Phys.* **15**, 1229-1241 (1982).

Key words: ionisation; linear polarization; monochromatic resonance; multiphoton; perturbation theory; radiation; sodium atom; time development; transient effects.

The time evolution of the ionisation probability of a sodium atom irradiated by linearly polarised light with frequency near the 3s-3p transition frequency is studied theoretically by the following method: The 3s and 3p states are strongly coupled using the rotating-wave approximation and then the resulting strongly coupled wavefunction is used as the lowest-order approximation in applying second-order perturbation theory to obtain the ionisation probability. The photoelectron energy spectrum and total ionisation probability are studied for various laser detunings and turn-on forms. Processes which are forbidden at long times by energy conservation are found to be important at short times ( $t < 10^{-9}$  s for a laser intensity of order  $\text{MW cm}^{-2}$ ). The ionisation probability is found to exhibit a plateau behaviour at times much less than the 3s-3p Rabi cycling time and subsequently to oscillate with the 3p population before reaching rate behaviour in the long-time limit.

- 21076.** Clarke, J. T.; Moos, H. W.; Feldman, P. D. The far-ultraviolet spectra and geometric albedos of Jupiter and Saturn, *Astrophys. J.* **255**, No. 2, 806-818 (Apr. 15, 1982).

Key words: planets, abundances; planets, atmospheres; planets, Jupiter; planets, Saturn; planets, spectra; ultraviolet, spectra.

Photometrically calibrated spectra (1200-1940 Å) of Jupiter and of Saturn, compiled from *IUE* observations over the period 1978 December through 1980 July, are presented along with the resulting wavelength variation of the geometric albedos of these planets. Airglow emission features from both planets at H I Ly $\alpha$  (1216 Å), C I (1657 Å), and the H<sub>2</sub> Lyman and Werner bands (1230-1608 Å) are identified; probable excitation mechanisms for these emissions are discussed. Relative to Jupiter, Saturn shows the C<sub>2</sub>H<sub>2</sub> absorption bands more strongly and has a lower value of the albedo for  $\lambda < 1750$  Å. A model of the atmospheric absorption was constructed using experimental photoabsorption cross sections and assuming homogeneous mixing in order to investigate the abundances of absorbing constituents in the upper part of the lower atmosphere. The best fit to the Jovian albedo data required assuming a C<sub>2</sub>H<sub>2</sub> concentration of  $\sim 1 \times 10^{-7}$  and the presence of an unidentified molecular or particulate absorber. North-south maps of the continuum emission from Jupiter show limb darkening; a comparison of equatorial and polar spectra indicates that the polar spectrum shows enhanced C<sub>2</sub>H<sub>2</sub> absorption and enhanced H<sub>2</sub> emissions which are weaker than those reported previously in auroral studies.

- 21077.** Dillon, M. A.; Spence, D. A new, optically forbidden Rydberg series in O<sub>2</sub> converging to the O<sub>2</sub><sup>+</sup>  $c^4\Sigma_u^-$  limit, *J. Chem. Phys.* **74**, No. 11, 6070-6074 (June 1, 1981).

Key words: angular distributions;  $c^4\Sigma_u^-$  limit; electrons; experimental; inelastic scattering; O<sub>2</sub>; Rydberg series.

We have measured the angular dependence of inelastically scattered electrons in O<sub>2</sub> in the energy-loss range 16 to 26 eV for incident electron energies between 75 and 400 eV, and for scattering angles between 2° and 12°. For high incident energy and low scattering angle our energy loss spectra correspond to the known optical absorption spectrum. At higher scattering angles, four new structures appear in our spectra at 21.85, 23.30, 23.80, and 24.06 eV. These four structures are the lowest members of the first optically forbidden Rydberg series observed to converge to the O<sub>2</sub><sup>+</sup>  $c^4\Sigma_u^-$  limit at 24.56 eV. The calculated quantum defects for these levels are about 0.75. This value, combined with angular scattering propensity rules, indicates that the new Rydberg states occur by promotion of an electron from the  $\sigma_{g,2s}$  orbital to  $n\pi\sigma_u$  orbitals, where  $n=3,4,5,6$ . A consideration of the propensity rules for excitation of forbidden

transitions by high energy electron impact suggest the term symbol of the new Rydberg states to be  $^3\Sigma_g^-$ .

- 21078.** Hughey, L. R.; Williams, R. T.; Rife, J. C.; Nagel, D. J.; Peckerar, M. C. Instrumentation for XUV lithography at SURF-II, *Nucl. Instrum. Methods* **195**, 267-271 (1982).

Key words: energy deposition; extreme ultraviolet; high resolution; lithography; photoresists; synchrotron radiation.

A new beam line for X-ray lithography with photon energies near 100 eV has been installed on the SURF-II storage ring at the National Bureau of Standards. Vacuum isolation of the ring from the exposure chamber is achieved using both a thin carbon window and a baffle cooled to liquid nitrogen temperature. The design and performance of the beam line are described. Initial exposures of two photoresists of intermediate sensitivity show that the beam line will serve for production of test microcircuits.

- 21079.** Stockbauer, R.; Madden, R. P. Design of a high throughput grazing incidence monochromator for SURF II, *Nucl. Instrum. Methods* **195**, 207-213 (1982).

Key words: far ultraviolet radiation; grating; monochromator; synchrotron radiation; toroidal grating monochromator; vacuum ultraviolet monochromator.

Optimization and ray trace calculations have been completed for a high throughput, toroidal grating monochromator. Several unique features have been incorporated into the design. The instrument will use the electron beam as the entrance slit, taking advantage of the small vertical beam size and high brightness of SURF II. The grating will be placed as close as possible to the storage ring and will intercept 51 mrad of horizontal orbit and below 500 Å, the full vertical light output.

Three different gratings will be used to cover the ranges 30-90, 80-200 and 150-600 Å. Normally, multi-grating instruments vary only the grating ruling spacing to change ranges, keeping the toroid and monochromator geometries identical in the different ranges. This instrument will be optimized independently in each range using the optimum toroid and monochromator geometries. As a result, the exit arm length will change in going from the long to the middle wavelength range and the included angle will change from 162.2° to 173° in going to the shortest wavelength range.

- 21080.** Baker, G. A., Jr.; Kincaid, J. M. The continuous-spin Ising model,  $g_0\phi^4_{ij}$  field theory, and the renormalization group, *J. Stat. Phys.* **24**, No. 3, 469-483 (1981).

Key words: Boson field theory; high-temperature series expansions; hyperscaling relations; Ising ferromagnet; Padé and integral approximants; renormalization group.

We have used the method of high-temperature series expansions to investigate the critical point properties of a continuous-spin Ising model and  $g_0\phi^4_{ij}$  Euclidean field theory. We have computed through tenth order the high-temperature series expansions for the magnetization, susceptibility, second derivative of the susceptibility, and the second moment of the spin-spin correlation function on eight different lattices. Our analysis of these series is made using integral and Padé approximants. In three dimensions we find that hyperscaling fails for sufficiently Ising-like systems; the strong coupling limit of  $g_0\phi^4_{ij}$  depends on how the ultraviolet cutoff is removed. The level contours of the renormalized coupling constant for this model in the  $g_0$ , correlation-length plane exhibit a saddle point. If the ultraviolet cutoff is removed before  $g_0 \rightarrow \infty$ , the usual field theory results and the renormalization-group fixed point with hyperscaling is obtained. If the order of these limits is reversed, the Ising model limit where hyperscaling fails and the field theory is trivial is obtained. In four dimensions, we find that hyperscaling fails completely;  $g_0\phi^4_{ij}$  is trivial for all  $g_0$  when the ultraviolet cutoff is removed.

- 21081.** Galowin, L. S.; Swaffield, J. A.; Bridge, S. A. A computational method for unsteady partially filled pipe flow and finite solid velocity transport, *Proc. AIAA/ASME 3d Joint Thermophysics, Fluids, Plasma and Heat Transfer Conf., St. Louis, MO, June 7-11, 1982*, pp. 1-8 (American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, NY 10104, June 1982).



Key words: computational method; fluid mechanics; drainage piping; transient pipe flow; transient solid motion, pipe flows.

The unsteady flow equations defining partially filled unsteady pipe flow and solid transport were developed and shown to be capable of numerical solution by the method of characteristics. Comparisons between predicted and observed flow attenuation in pitched pipes confirmed the solution technique. A predictive model for solid transport, based upon the use of force and leakage flow relationships, provides the moving boundary condition about the solid for coupling with the method of characteristics solution for the transient analysis. Agreement between solid transport measurements and predicted results for solid velocities with input time dependent surge flow and for initiation of solid motion from rest with steady inflow was shown.

- 21082.** Dikkers, R. D. Solar energy system performance standards and criteria—NBS activities, *Proc. Second Solar Heating and Cooling Commercial Demonstration Program Contractors' Review, San Diego, CA, Dec. 13-15, 1978*, pp. 13-23 (U.S. Department of Energy, Washington, DC 20585, July 1979).

Key words: buildings; cooling; heating; hot water; performance criteria; solar energy; standards.

One of the important objectives of the National Program for Solar Heating and Cooling of Buildings is the development of "solar energy system performance standards and criteria for the production and installation of solar energy systems, subsystems and components with appropriate provisions for consumer protection." To assist the Department of Energy (DoE) and the Department of Housing and Urban Development (HUD) in accomplishing the above objective, the National Bureau of Standards (NBS) has been actively working with standards-writing organizations, industry, designers, consumers and other members of the building community for the past few years to help develop performance criteria and standards for solar heating and cooling applications. This overview paper describes the current status and highlights of NBS activities which are being carried out with financial support from DoE and HUD.

- 21083.** Ehrstein, J. R. Improved spreading resistance analysis of power control devices, (Proc. Electrochemical Soc. Meet., Los Angeles, CA, Oct. 14-19, 1979), *Extended Abstract No. 619*, pp. 1555-1556 (1979).

Key words: aluminum-doped silicon; dopant profiles; gallium doped silicon; resistivity profiles silicon; spreading resistance; thyristor.

Several recent improvements in the practice and analysis of spreading resistance measurements have particular importance for measurements on thyristors and similar power control devices. These include a procedure for obtaining greatly improved measurement precision on high resistivity n-type layers, improved understanding of the calibration of aluminum and gallium-doped layers, and an extremely efficient, yet accurate, algorithm for extracting dopant profiles from measurements. These improvements will be discussed and their impact on the use of spreading resistance-derived profiles for device modelling will be considered.

- 21084.** El Khadem, H. S.; Coxon, B. A nitrogen-15 n.m.r. study of some dehydro-L-ascorbic acid bis(phenylhydrazono) derivatives, *Carbohydr. Res.* 89, 321-325 (1981).

Key words: ascorbic acid derivatives; bis(phenylhydrazones); nitrogen-15; nitrogen-15 chemical shifts; nitrogen-15-proton coupling constants; n.m.r. spectroscopy.

The structures of two bis(phenylhydrazono) derivatives of ascorbic acid have been analyzed by natural abundance, nitrogen-15 n.m.r. spectroscopy at high field. The acetylated oxidation product of dehydro-L-ascorbic acid bis(phenylhydrazono) is shown to be a phenylazo, phenylhydrazono derivative, whereas the acetylated cyclization product of dehydro-L-ascorbic acid bis(phenylhydrazono) is proved to be a single *keto* tautomer of a 1-phenyl-4-phenylhydrazono-pyrazolin-5-one derivative.

- 21085.** Feldman, A.; Waxler, R. M. Dispersion of the piezobirefringence of GaAs due to strain-dependent lattice effects, *J. Appl. Phys.* 53, No. 3, 1477-1483 (Mar. 1982).

Key words: dispersion; effective charge; GaAs; gallium arsenid; infrared elasto-optic; optic phonon; oscillator strength; photoelastic; piezobirefringence.

The piezobirefringence of GaAs has been measured over the wavelength range 3.5–10.6  $\mu\text{m}$ . A small yet significant dispersion is found which is attributed to the strain dependence of the transverse optic phonon. The main contribution to the dispersion appears to be due to the strain-induced anisotropy of the transverse effective charge. The data are in reasonably good agreement with the theory of Humphreys and Maradudin. The strain-induced relative anisotropies of the transverse effective-charge and the high-frequency photoelastic constants  $k_{11}^{\omega}-k_{12}^{\omega}$  and  $k_{44}^{\omega}$  have been calculated on the basis of a two-parameter fit to the photoelastic dispersion.

- 21086.** Deslattes, R. D.; Kessler, E. G., Jr. Precision gamma- and x-ray energies, *Proc. Conf. Atomic Masses and Fundamental Constants 6 (1980)*, Ann Arbor, MI, Sept. 18-20, 1979, J. A. Nolen, Jr. and W. Benenson, eds., pp. 203-218 (Plenum Publ. Corp., 227 West 17th Street, New York, NY 10011, 1980).

Key words: crystal diffraction; gamma-ray standards; precision measurement; x-ray interferometry; x rays.

At this time, it has been possible to redetermine a small but significant group of  $\gamma$ -ray reference energies ( $0.6 < E < 1.1$  MeV) in terms of the Rydberg constant,  $R_{\infty}$ . This work has made use of an  $I_2$  molecularly stabilized laser to link Doppler-free spectroscopy of hydrogen with achromatic procedures for crystal spacing determination. Crystals calibrated in this way (after suitable transfer measurements) have been used to determine X-ray and  $\gamma$ -ray transition energies using flat-crystal instruments whose angular scales were established to high accuracy from first principles. Our procedures and most available results have been reported elsewhere but, for the sake of completeness, they are briefly reviewed in this report.

Our main aim is to summarize applications thus far and to examine the technical problems and potential interest which may follow from extension of these techniques to higher energies. Up to the present time,  $\gamma$ -ray transitions have been observed only from relatively intense and long-lived sources produced in a reactor and transported to a two flat-crystal instrument. Extension to higher  $\gamma$ -ray energies requires use of in-pile capture sources and hence an instrument with a stationary entrance port. Such a second generation instrument has been built and is now active in the study of K-series X-rays from mid- to high-Z elements produced with a 4 MeV electron Van de Graaff.

- 21087.** Celotta, R. J.; Pierce, D. T.; Siegmann, H. C.; Unguris, J. An electron spin polarization detector: Spin-dependent absorption of a polarized electron beam, *Appl. Phys. Lett.* 38, No. 7, 577-579 (Apr. 1, 1981).

Key words: amorphous ferromagnet; exchange interaction; spin detector; spin-orbit interaction; spin polarization.

The exchange interaction and the spin-orbit interaction are observed to cause a spin dependence of the absorption of a polarized electron beam in the amorphous ferromagnet  $\text{Ni}_{40}\text{Fe}_{60}\text{B}_{20}$  and a W(100) single crystal respectively. The enhancement of the spin dependence, near the energy where the secondary electron yield is unity, is shown to provide a simple efficient detector of spin polarization.

- 21088.** Berland, M.; Burek, A.; Dhez, P.; Esteve, J. M.; Gauthé, B.; Karnatak, R. C.; LaVilla, R. E. Reflectivity and resolution measurements of metallic multilayers, beryl, and potassium acid phthalate (KAP) with synchrotron radiation in the 1 keV region, *SPIE* 316, 169-172 (Society of Photo-Optical Instrumentation Engineers, Box 10, Bellingham, WA 98227-0010, 1981).

Key words: beryl; KAP; metallic multilayers; reflectivity; resolving power; synchrotron radiation; 1 keV photon energy region.

A recently constructed reflectometer at LURE used with monochromatized intense synchrotron radiation offers new possibilities for absolute measurements of reflectivity and resolution for metallic multilayers, and natural and synthetic crystals in a wide range of wavelengths. Contrary to the procedure generally used for the reflectivity measurements, in the present arrangement the crystal



or multilayer is set at a fixed angle  $\theta_0$  corresponding to a desired energy  $E_0$  and the energy of the highly polarized incident photon beam is varied around this value by means of a double crystal monochromator. The reflectivity versus energy for a given polarization are obtained directly for the sample crystal. In this communication we give the first examples for the absolute reflectivity and resolution measurements around 1 keV of metallic multilayers, beryl and KAP thus illustrating the potential application of this method.

**21089.** Babrauskas, V. Estimating room flashover potential, *Fire Technol.* 16, No. 2, 94-104 (May 1980).

Key words: burning rate; compartment fires; flammability regulations; flashover; furniture flammability; room fire tests.

Flashover is the ultimate event in a room fire signaling the final untenability for room occupants and greatly increased hazard to other building spaces. Despite this importance, hazard evaluations of furnishings and other common fuel loads have normally not been based on estimates of flashover potential. This paper considers a simple combustion model and examines available experimental data.

**21090.** Cohen, M.; Kear, B. H.; Mehrabian, R. Rapid solidification processing—An outlook, Paper in *Rapid Solidification Processing: Principles and Technologies II*, 1-24 (Claitor's Law Books & Publ. Division Inc., Baton Rouge, LA, 1980).

Key words: amorphous; cooling rate; crystalline; dendrites; interfaces; microcrystalline; nucleation; recalescence; solidification; undercooling.

Materials processing plays a central role in the general field of materials science and engineering; indeed, the recent surge of R&D activity in rapid solidification processing (RSP) provides a further example of how the advent of a processing method can catalyze new ideas across the wide spectrum of materials structure, properties, and performance. The major attention in RSP thus far has been directed toward achieving fast cooling rates from the pre-alloyed liquid state, in the expectation that cost-beneficial properties in final shapes of technological importance can be obtained. Such processes typically involve (a) the solidification of small droplets, followed by their subsequent consolidation via powder-metallurgy techniques into bulk pieces, or (b) the melt spinning of continuous or discontinuous lengths of thin ribbons, or (c) the in-situ melting and solidification of thin surface layers.

Lagging behind, however, is a more basic understanding of the essential phenomena at play in RSP: (a) mechanisms and kinetics of nucleation and growth during rapid solidification; (b) connections between rapid solidification modes and resulting structures; (c) characterization of RSP fine-scale structures; and (d) definitive structure/property relationships to disclose which elements of the RSP structure are actually contributing to the novel properties being observed.

If RSP is to fulfill its promise for advanced technological applications, it is crucial to establish a sound body of knowledge for connecting the associated improvements in properties and performance back to the underlying microstructures as well as how the microstructures are attained.

**21091.** Forman, R. A.; Bell, M. I.; Myers, D. R. Comments on "Raman scattering from boron-implanted laser annealed silicon", *J. Appl. Phys.* 52, No. 6, 4337-4339 (June 1981).

Key words: annealing; boron; ion implantation; laser annealing; local mode; optical spectra; phonons; Raman spectra; silicon; spectra; thermal annealing.

Measurements have been made of the Raman spectra of silicon implanted with either  $^{11}\text{B}$  or  $^{10}\text{B}$  and subsequently thermally annealed. These measurements, taken with an argon-ion laser operating at 514.5 nm and at room temperature, revealed the presence of an intrinsic two-phonon combination band underlying the  $^{11}\text{B}$  local mode. The coincidence of these two spectral features complicates the analysis of the annealing process as diagnosed on the basis of the Raman spectrum. The use of the  $^{10}\text{B}$  isotope, and its spectra, minimizes ambiguities in interpretation of the spectra of ion-implanted silicon. Reexamination of the earlier annealing studies of Engstrom and Bates is suggested on the basis of the present results.

**21092.** Babrauskas, V. Fire tests and hazard analysis of upholstered chairs, *Fire J.* 74, No. 2, 35-39 (Mar. 1980).

Key words: chairs; compartment fires; fire tests; flammability; furnishings; upholstered furniture.

A test program was conducted to determine the fire behavior of a variety of upholstered chairs subjected to a flaming ignition. Major variables were materials and construction of chairs, room ventilation and type of ignition sources. A total of 16 types of traditional and modern design chairs were tested in a full-scale, otherwise unfurnished room. A folded up newspaper at the seat area was used as the standard ignition source. Room tenability criteria were based on smoke, concentrations of gaseous combustion products, and heat flux. One or more tenability criteria were exceeded for 14 chairs, in times ranging from 100 sec to 650 sec; two chairs burned without exceeding any of the tenability criteria.

**21093.** Babrauskas, V. A closed-form approximation for post-flashover compartment fire temperatures, *Fire Safety J.* 4, 63-73 (1981).

Key words: compartment fires; fire endurance; fire engineering design; liquid pool fires; thermoplastic pool fires; wood crib fires.

A method is developed, suitable for design purposes, which allows approximate post-flashover fire temperatures to be calculated without the use of computer codes. This method may be used for thermoplastic pool fires, wood crib fires, and other fires of known fuel release rate. Both ventilation-limited and fuel rate-limited fires are treated. Results typically agree to within 3% of exact computer code solutions.

**21094.** Babrauskas, V. Flame lengths under ceilings, *Fire Mater.* 4, No. 3, 119-126 (1980).

Key words: ceiling entrainment; fire flame length; plume fires.

The evaluation of hazards from developing room fires often requires a knowledge of flame lengths developed by burning objects. Procedures for estimating flame lengths have been available only for vertical plume fires, where there is no flame impingement on the room ceiling. Computational procedures are developed for approximate calculation of flame lengths when part of the flame flow is along the ceiling. Four common geometries are treated: unbounded ceiling, plume near corner, plume in corner and one-directional corridor spread. Ceiling flame lengths are calculated by use of the assumption that the total air entrained up to the flame tip is the same for ceiling flow as for the free fire. Comparison with limited experimental data suggests potential for prediction in full-scale room fires.

**21095.** Babrauskas, V. Applications of predictive smoke measurements, *J. Fire Flammability* 12, 51-64 (Jan. 1981).

Key words: furnishings; furniture; mattress flammability; room fire tests; smoke density chamber; smoke measurement.

Simple theoretical considerations can be used to establish the proper smoke quantities that are preserved between small-scale and full-scale tests. By proper analysis, measurements taken in a sealed box test can be applied predictively to full-scale fire flows. Specific extinction area is identified as the variable to be measured. Data from the combustion of institutional mattresses show the improved predictiveness of specific extinction area over the more commonly specified specific optical density. Analysis suggests 0.5 to 20 percent of the specimen mass loss is converted into obscuring particulates.

**21096.** Shukla, R. C.; Mountain, R. D. Debye-Waller factor of bcc metals: A comparison of the lattice-dynamics and molecular-dynamics results for Li and Rb, *Phys. Rev. B* 25, No. 6, 3649-3657 (Mar. 15, 1982).

Key words: anharmonic effects; Debye-Waller factor; lattice dynamics; lithium; molecular dynamics; rubidium.

We present a method for the numerical calculation of the anharmonic contributions to the Debye-Waller factor (DWF) for metals involving long-range interactions. The numerical results of DWF obtained by the above method are compared with those of a molecular-dynamics calculation for a sixth-neighbor-interaction model of Li and Rb. It is shown that an excellent agreement is achieved between the results calculated by the two methods for the same



model of the crystal potential. For Li and Rb the anharmonic contribution to DWF of  $O(|\vec{q}|^2)$ , where  $\vec{q}$  is the wave vector, is about 10% of the quasi-harmonic contribution at  $T \sim T_m$  ( $T_m$  is the melting temperature). The two other anharmonic contributions of  $O(|\vec{q}|^4)$  to DWF are found to be negligible in Li and Rb even when  $T \sim T_m$ .

- 21097.** Rosenstock, H. M.; Buff, R.; Ferreira, M. A. A.; Lias, S. G.; Parr, A. C.; Stockbauer, R. L.; Holmes, J. L. Fragmentation mechanism and energetics of some alkyl halide ions, *J. Am. Chem. Soc.* 104, No. 9, 2337-2345 (May 1, 1982).

Key words: alkyl halide; breakdown curve; metastable transition; photoelectron photoion coincidence; propylene; proton affinity.

Halogen loss from iodoethane, 1-bromopropane, 2-bromopropane, 1-iodopropane, and 2-iodopropane has been studied by means of electron-ion coincidence techniques and by observation of metastable transition. Analysis of the breakdown curves and the study of residence times gave the zero-kelvin thresholds for halogen loss and indicated the size of the kinetic shift. The fragmentation onset for iodoethane was located in a Franck-Condon gap. The zero-kelvin thresholds for the propyl halides were found to lie at or just above the upper spin-orbit level of the parent ion. All of the propyl halides exhibited a unimolecular metastable transition. At fragmentation onset the 2-halopropane ions have negligible fragment kinetic energy while the 1-halopropane produce secondary propyl ions with 100–200 meV of kinetic energy. It was established that a potential barrier must be surmounted in this fragmentation-isomerization process and analysis suggests a dynamic mechanism other than conventional QET, for example, weak couplings of vibrational modes. Analysis of the 2-halopropane fragmentation thresholds leads to an accurate, absolute value for the proton affinity of propylene,  $751.4 \pm 2.9$  kJ/mol at room temperature. This value reconciles some differences inherent in the proton affinity scale based on various relative measurements.

- 21098.** Proctor, T. M., Jr. An improved piezoelectric acoustic emission transducer, *J. Acoust. Soc. Am.* 71, No. 5, 1163-1168 (May 1982).

Key words: acoustic emission; elastic wave; nondestructive evaluation; Rayleigh wave; transducer; ultrasonic.

A piezoelectric transducer has been designed and developed that has promise of being a high fidelity acoustic emission (AE) transducer [T. M. Proctor, Jr., *J. Acoust. Soc. Am. Suppl.* 1 68, S568 (1980)]. Small transducer contact area, elimination of acoustical interference effects associated with certain geometries, and redistribution of the arrival times of reflected signals originating from various elements of the transducer were the guiding criteria in the design. This transducer consists of a conical active element and an extended backing. The transducer's performance has been compared to a line capacitance transducer using surface wave signals. These comparisons indicate an amplitude response which is flat within  $\pm 3$  dB for the frequency range of 50 kHz to 1 MHz. The over-all displacement sensitivity is nominally  $2 \times 10^8$  V/m. Factors that influence frequency response such as backing geometry and aperture size have been experimentally investigated and results are reported.

- 21099.** Parr, A. C. Status report on the SURF II facility at NBS, *Nucl. Instrum. Methods* 195, 7-15 (1982).

Key words: photoelectron spectroscopy; surface science; synchrotron radiation.

The facilities and experimental program at SURF II (Synchrotron Ultraviolet Radiation Facility) are reported on. The planned upgrading of the storage ring and new beam lines are discussed.

- 21100.** Netzer, F. P.; Madey, T. E. The structure of CO on Ni(111), *J. Chem. Phys.* 76, No. 1, 710-715 (Jan. 1, 1982).

Key words: adsorption; carbon monoxide on Ni(111); electron stimulated desorption; ESDIAD; low energy electron diffraction; thermal desorption.

Electron stimulated desorption ion angular distributions (ESDIAD), low energy electron diffraction (LEED), and temperature programmed thermal desorption (TPD) have been used to study the adsorption of CO on Ni(111) in the temperature range 80–300 K. For low coverages, the CO layer is disordered; a  $c(4 \times 2)$  pattern appears at coverages  $\theta \sim 0.5$ , the maximum coverage at 300 K.

At temperatures 220–240 K, a well-ordered  $(\sqrt{7/2} \times \sqrt{7/2})R 19^\circ$  LEED pattern forms at saturation ( $\theta \sim 0.57$ ). At 80 K, the CO saturation layer is characterized by a "complex" LEED pattern. Only one binding state is seen in TPD for  $\theta \leq 0.40$  (peak temperatures 450–430 K); species having lower desorption temperatures populate at higher coverage. At 300 K adsorption the only ESD ion observed is  $O^+$ , with desorption centered about the direction perpendicular to the surface. The  $O^+$  ion yield shows a maximum at intermediate coverages.  $CO^+$  ions are also observed at adsorption temperature  $< 300$  K at higher coverages. The ESDIAD patterns for saturation coverage in the range 80–260 K indicate off-normal ion emission in addition to the normal component. The data suggest that for  $\theta \leq 0.5$ , CO is adsorbed in multiply coordinated sites with the molecular axis perpendicular to the surface. At temperatures  $< 300$  K, a fraction of CO can adsorb in singly coordinated sites as well. Upon heating the CO layer formed at 80 K ( $\theta \sim 0.57$ ) the  $CO^+$  ion yield maximizes at  $\sim 240$  K when the  $(\sqrt{7/2} \times \sqrt{7/2})R 19^\circ$  LEED pattern is well defined. The  $CO^+$  yield therefore reflects the ordering behavior in the adsorbate layer at temperatures below the onset of desorption and indicates a shift of a fraction of CO molecules from multiply coordinated to singly coordinated sites. Finally, a model is proposed involving resonance charge exchange between adsorbed CO molecules to account for the observed variations of the  $O^+$  yield with surface coverage.

- 21101.** Matthew, J. A. D. Spin dependence of the electron inelastic mean free path and the elastic scattering cross section—A high-energy atomic approximation, *Phys. Rev. B* 25, No. 5, 3326-3332 (Mar. 1, 1982).

Key words: elastic scattering cross section; inelastic scattering cross section; spin-dependent scattering.

The spin dependences of the inelastic scattering cross section (inverse mean free path) and the elastic scattering cross section are calculated for polarized electrons scattered from oriented atoms in the Born-Ockhur approximation with a view to understanding spin-dependent scattering in ferromagnets. In the medium-to-high-energy range ( $\geq 100$  eV) the elastic scattering for parallel spins is greater than for antiparallel spins, while the inelastic cross section for parallel spins is less than for antiparallel. Elastic spin dependence appears to be greater than inelastic, and the exchange effects fall off rapidly with increasing energy. The relation of this atomistic scattering approach to solid-state models is discussed.

- 21102.** Harvey, K. C. Slow metastable atomic hydrogen beam by optical pumping, *J. Appl. Phys.* 53, No. 5, 3383-3386 (May 1982).

Key words: atomic beam; hydrogen; metastable states; optical pumping.

A beam source of atomic hydrogen is described which produces metastable atoms in the  $2S_{1/2}$  state by optical pumping. A beam flux of  $10^{16}$  atoms/s is generated in the ground state. The atoms in the beam pass in front of a lamp producing Lyman- $\beta$  (1026 Å) radiation, where some of them are excited to the  $3P$  level and cascade with a branching ratio of 12% to the  $2S_{1/2}$  state. The number of metastable atoms produced is measured by quenching them with an electric field and detecting the emitted Lyman- $\alpha$  (1216 Å) radiation. Beams of  $10^6$  metastable atoms/s were obtained. Using the Bethe-Lamb theory for the quenching process, a metastable beam effective temperature of 100 K was measured.

- 21103.** Doane, L. M.; Fatiadi, A. J. Electrochemical oxidation of several oxocarbon salts in *N,N*-dimethylformamide, *J. Electroanal. Chem.* 135, 193-209 (1982).

Key words: croconates; dicyanomethylene; electrochemical; electron-transfer; mechanism; oxidation; reversible; salts.

The oxocarbon salts of croconic acid and its dicyanomethylene derivatives have been shown to undergo two consecutive reversible one-electron transfers in *N,N*-dimethylformamide to produce stable radical anions and the neutral croconates. Disproportionation equilibrium constants were found to be quite small for all the croconate radical anions investigated. Following chemical reactions accompanied the second oxidation process of dicyanomethylene-substituted croconates. Substituent effects were shown to be ring position-independent and are discussed with respect to the unique resonance structure of the croconates.



**21104.** Bryant, G. W.; Glick, A. J. The importance of impurity states in doped trans-polyacetylene, *J. Phys. C: Solid State Phys.* **15**, L391-L396 (1982).

Key words: doping; impurity states; midgap absorption; nonhydrogenic states; polaron; polyacetylene; soliton.

We assess the importance of the impurity states of a doped trans-polyacetylene chain. The impurity potential is modelled by a point charge that is located off the chain and screened phenomenologically with the bulk dielectric constant. The common assumption that the impurity levels of a dimerised chain closely approximate the hydrogenic levels of a point charge impurity is invalid when the impurity is not on the chain. Additional non-hydrogenic states occur. One of the new states is much deeper in the gap. The formation energies for charged soliton and charged polaron lattice distortions are found by solving the Su-Schrieffer-Heeger model for polyacetylene with an impurity added. The impurity states severely modify the structure of the soliton distortion. The charged polaron distortion, not the charged soliton distortion, is the most stable distortion that can be formed during doping with gap states consistent with the observed mid-gap absorption.

**21105.** Egelhoff, W. F., Jr.; Tibbetts, G. G. Photoemission studies of a mixed valent ytterbium aluminum alloy, *Proc. VI Int. Conf. Vacuum Ultraviolet Radiation Physics, Charlottesville, VA, June 2-6, 1980*, I-20, pp. 1-3 (University of Virginia, Charlottesville, VA, 1980).

Key words: Auger; core-holes; mixed-valence; photoionization; resonance; ytterbium.

A valence change from  $f^{13}$  to  $f^{14}$  occurs in ytterbium atoms in a mixed-valent ytterbium-aluminum alloy during autoionization and Auger-electron emission. In both of these emission processes the 4f-shell occupancy increases when the shell becomes more tightly bound under the influence of the core hole. The quenching of the core hole, which terminates the process, occurs after the valence change, so that the  $f^{13}$  initial state is not manifest in the spectra.

**21106.** Dikkers, R. D. Standards for solar energy systems, *Proc. 1980 ASQC Technical Conf. Transactions, Atlanta, GA, May 20-22, 1980*, pp. 201-208 (American Society of Quality Control, 161 West Wisconsin Avenue, Milwaukee, WI 53203, 1980).

Key words: biomass; heating and cooling; performance criteria; photovoltaics; solar energy systems; standards; wind energy.

One of the major findings reported in the Domestic Policy Review of Solar Energy was that "limited public awareness of and confidence in solar technologies is a major barrier to accelerated solar energy use." Accordingly, President Carter has recommended that private sector and governmental activities to develop equipment performance standards, testing and certification need to be coordinated and accelerated. This paper describes some of the major program efforts which are underway in both the public and private sectors to develop and evaluate standards for various solar energy systems (heating and cooling, photovoltaics, wind, biomass). Some of the important program accomplishments are also discussed.

**21107.** Ehrstein, J. R. Some considerations regarding thin film standards for the semiconductor industry, *Proc. Microelectronics Measurement Technology Semin., San Jose, CA, Mar. 11-12, 1980*, pp. 324-331 (Benwill Publ. Corp., 1050 Commonwealth Avenue, Boston, MA 02215).

Key words: ellipsometry; polysilicon films; silicon dioxide films; silicon nitride films; standard reference materials; thin films.

Semiconductor integrated circuit manufacturing has witnessed a rapid evolution of processing techniques and a reduction of structural dimensions. This has placed a great burden on metrology for process development and for process monitoring, both because of the smallness of the dimensions involved and the variety of interferences encountered in measuring differing structural combinations of thin films. One possible means for improving the uniformity and control of semiconductor thin film measurement would be through the use of certified thickness standards, such as have been requested of the Standard Reference Material Program at the National Bureau of

Standards.

This paper will first consider some of the requisite properties of Standard Reference Materials (SRM's) for effective use in improving the uniformity of measurements. It will then consider some of the limitations imposed by real world thin film specimens and our state of understanding of their properties as well as by the different types of measurements available. Finally, the need for improved measurement control will be related to the SRM program in light of these limitations.

**21108.** Wenzel, J. T.; Sanders, D. M. Sodium and boron vaporisation from a boric oxide and a borosilicate glass melt, *Phys. Chem. Glasses* **23**, No. 2, 47-52 (Apr. 1982).

Key words: boric oxide; glass; sodium boron; sodium borosilicate; thermodynamics; transpiration; vaporization.

Reactive vaporisation studies of a boric oxide and a 1:1:4 sodium borosilicate glass melt were conducted using a stirrable transpiration apparatus which allowed the melt surface to be replenished continuously. Both boron and sodium vapour densities could be measured as a function of water vapour pressure.

Water vapour enhances the vaporisation of boric oxide due to the formation of boric and metaboric acids, but it has little effect on the vaporisation of sodium and boron from the sodium borosilicate. If this latter melt is left unstirred, the vapour density decreases because of surface depletion of sodium borate.

**21109.** Deslattes, R. D.; Kessler, E. G., Jr.; Jacobs, L.; Schwitz, W. Selected x-ray data for comparison with theory, *Phys. Lett.* **71A**, Nos. 5/6, 411-414 (May 28, 1979).

Key words: experimental/theoretical comparisons; precision x-ray energies.

By combining a few recently available optically referenced X-ray measurements with a highly selected group of previously reported X-ray to X-ray and X-ray to  $\gamma$ -ray ratios, we obtain a set of accurate X-ray transition energies. Comparison with recent theoretical calculations in the relaxed orbital limit of the relativistic self-consistent field approximation leads to a clearer delineation of the trend of discrepancies than has hitherto been available. The resulting linear variation of the discrepancies with  $Z$  appears to call for explanation.

**21110.** Young, R. A.; Brown, W. E. Structures of biological minerals, (Proc. Dahlem Konferenzen, Berlin, Germany, Oct. 18-23, 1981), Paper in *Biological Mineralization and Demineralization*, G. H. Nancollas, ed., pp. 101-141 (Springer-Verlag, Berlin, Germany, 1982).

Key words: biominerals; calcium carbonates; calcium oxalates; calcium phosphates; calcium pyrophosphate; crystal structures; hydroxyapatite; octacalcium phosphate; sodium urate.

The basic chemical and physical properties of ionic crystals reside in their structures. Structures of the following compounds of biological interest are described: calcium phosphates, a urate, calcium carbonates, and calcium oxalates. To a considerable degree their properties are affected by the presence of impurities and lattice defects in the crystals. In keeping with this, the kinds and locations of impurities and defects in hydroxyapatite are discussed, with special reference to how these affect the transport of ions along the hexagonal channels of hydroxyapatite. The crystal structure of octacalcium phosphate, which has a special relationship to that of hydroxyapatite, is described. The ways in which octacalcium phosphate may affect the growth mechanisms, impurity-defect content, morphology, stoichiometry, and chemical properties of hydroxyapatite are described. It is shown that much of the variability in the chemistry of the  $\beta$ - $\text{Ca}_3(\text{PO}_4)_2$ -whitlockite series of compounds resides in one of the 21 calciums in a unit cell. It is suggested that the hydrated compounds in all these series of biominerals may have special roles during the nucleation stage, and subsequently because they usually grow more rapidly than the anhydrous forms. The structure of  $\text{CaCO}_3 \cdot 6\text{H}_2\text{O}$  contains  $\text{CaCO}_3$  ion pairs entirely isolated from each other by surrounding water molecules; this structural unit may participate in various important biochemical processes.

**21111.** Fields, R. J.; Smith, J. H. Mechanical testing in the 80's, *Met.*



Key words: computer controlled mechanical test; crack growth; creep-fatigue; mechanical testing; multiaxial tests; stress-corrosion.

A forecast is made of the types of mechanical tests of materials that will be important in the next decade. This forecast is based on known, recent changes in technologies which use and rely on mechanical test data. There will be a strong emphasis on multiaxial tests in the 80's and on crack growth studies under combined conditions of stress, corrosion, and high temperature.

21112. Holland, D. M. P.; Parr, A. C.; Ederer, D. L.; Dehmer, J. L.; West, J. B. The angular distribution parameters of argon, krypton and xenon for use in calibration of electron spectrometers, *Nucl. Instrum. Methods* 195, 331-337 (1982).

Key words: asymmetry parameter; spectroscopy.

Measurements are presented of the angular distribution parameter for the photoejected valence electrons of argon, krypton and xenon, from threshold to  $h\nu \approx 25$  eV. The experimental arrangement at the NBS (SURF II) storage ring is described and the method of data analysis discussed. The results are compared with other experimental data and theoretical predictions.

21113. Hermann, H. W.; Leone, S. R. Photofragment infrared emission spectroscopy: Vibrational progression and potential parameters of the  $\text{CH}_3(\nu_2)$  "umbrella" mode, *J. Chem. Phys.* 76, No. 10, 4759-4765 (May 15, 1982).

Key words: methyl iodide ( $\text{CH}_3\text{I}$ ); methyl radical ( $\text{CH}_3$ ); photodissociation; photofragmentation.

The out-of-plane bending vibration ( $\nu_2$ ) of the free radical  $\text{CH}_3$  has been detected by time and wavelength-resolved infrared emission spectroscopy following dissociation of  $\text{CH}_3\text{I}$  with a pulsed laser at  $\lambda = 266$  nm. Three distinct  $Q$  branch features in the vibrational progression of the  $\nu_2$  "umbrella" mode are observed: 3-2 ( $729 \pm 4$   $\text{cm}^{-1}$ ), 4-3 ( $772 \pm 4$   $\text{cm}^{-1}$ ), and 5-4 ( $811 \pm 4$   $\text{cm}^{-1}$ ). These low resolution measurements provide an approximate determination of the harmonic/quartic mixed oscillator potential parameters for the higher levels of the out-of-plane bend. The vibrational assignment is important to studies of radical excitation originating from photodissociation, which is considered in the accompanying paper.

21114. Hermann, H. W.; Leone, S. R. Photofragmentation dynamics of  $\text{CH}_3\text{I}$  at 248 and 266 nm: Vibrational distributions in the  $\text{CH}_3(\nu_2)$  "umbrella" mode, *J. Chem. Phys.* 76, No. 10, 4766-4774 (May 15, 1982).

Key words: methyl iodide ( $\text{CH}_3\text{I}$ ); methyl radical ( $\text{CH}_3$ ); photodissociation; photofragmentation.

Vibrational population distributions in the  $\nu_2$  out-of-plane bending mode of  $\text{CH}_3$  when produced by photofragmentation of  $\text{CH}_3\text{I}$  at 266 and 248 nm are analyzed by infrared emission spectroscopy. In both cases, there is excitation of the "umbrella" mode vibration up to 10 quanta, and the peak of the excitation occurs at  $\nu_2 = 2$  for both wavelengths. The vibrational distribution produced at 266 nm agrees well with molecular beam time-of-flight results. The distribution at 248 nm is only moderately enhanced, in contradiction to theoretical predictions which suggest that the peak of the distribution should be shifted to  $\nu_2 = 5$ . The infrared emission spectra suggest that there is no additional rotational excitation in the radical over the ambient rotational temperature of the parent  $\text{CH}_3\text{I}$ . In addition, there is no detectable excitation in other vibrational modes, produced either directly in the dissociation or upon collisions.

21115. Helmcke, J.; Lee, S. A.; Hall, J. L. Dye laser spectrometer for ultrahigh spectral resolution: Design and performance, *Appl. Opt.* 21, No. 9, 1686-1694 (May 1, 1982).

Key words: dye laser stabilization; laser frequency stabilization; laser spectroscopy.

A dye laser spectrometer for ultrahigh spectral resolution is described. The laser frequency is stabilized to the side of a transmission fringe of an optical cavity by means of the usual differencing servo technique. With an intralaser-cavity AD\*P phase

modulator, driven by improved fast servo electronics, the linewidth of the jet stream dye laser was reduced to 1.8 kHz rms. With fast amplitude stabilization a 1.0-kHz line-width was observed. Good long-term stability and digital frequency scanning (with a step resolution of 1 kHz and a continuous tuning range of 900 MHz) are accomplished by transferring the long-term stability of an  $I_2$ -stabilized He-Ne laser to the dye laser via a second optical cavity and an offset locked He-Ne laser. A drift rate of  $< 1$  kHz/min was obtained while using this dye laser spectrometer to investigate two-photon optical Ramsey fringes. A fringe width of the Ramsey features of 17 kHz has been observed, confirming for the first time the high resolution capability of two-photon optical Ramsey resonances.

21116. Burnett, K.; Cooper, J.; Kleiber, P. D.; Ben-Reuven, A. Collisional redistribution of radiation in strong fields: Modification of the collision dynamics, *Phys. Rev. A* 25, No. 3, 1345-1357 (Mar. 1982).

Key words: atomic collisions; intense laser fields; laser induced chemistry.

We extend the theory of light scattering from an atom undergoing collisions to the case of strong laser fields, where the expansion in powers of  $\Omega\tau_c$  that was used formerly in a series of papers by Burnett *et al.* breaks down. In particular we consider in detail the conditions necessary to relate the observable quantities to intense-field collisional rate constants in a dressed-state basis (such as those calculated by Light and Szöke). We also show (following Rabin and Ben-Reuven) that by studying the spectrum emitted by the atoms in the presence of a strong field one may measure the collisional rates for transfer between the dressed states of atom plus radiation field.

21117. Mickens, R. E. A regular perturbation technique for nonlinearly coupled oscillators in resonance, *J. Sound Vib.* 81, No. 2, 307-310 (1982).

Key words: coupled nonlinear oscillators; nonlinear analysis; perturbation theory.

We present a regular perturbation technique for obtaining uniformly valid solutions to systems of weakly coupled nonlinear oscillators which satisfy a resonance condition. The technique allows for the easy determination of possible limit cycles and limit points. To illustrate the procedure, we apply it to a system having two degrees of freedom.

21118. Gross, D. Progress on fire safety standards—Fire standards activities in ASTM, *Fire Mater.* 5, No. 4, 177-178 (1981).

Key words: building fires; building materials; committees; fire tests; flashover; room fires; standards.

The American Society for Testing and Materials (ASTM) is the largest standards-writing organization in America, providing voluntary consensus standards for materials, products, systems and services. ASTM Committee E5 on Fire Standards is a committee responsible for the development, revision and approval of fire standards used to assess the fire performance of materials, products, assemblies and systems.

21119. Dikkers, R. D. Passive solar standards, performance criteria and code provisions, *Proc. U.S. Dept. of Energy Passive & Hybrid Solar Energy Program Update Meet., Washington, DC, Sept. 21-24, 1980*, pp. 2-9-2-11 (U.S. Department of Energy, Washington, DC 20585, 1980).

Key words: code provisions; passive solar systems; performance criteria; solar energy; standards; test procedures.

The development of performance standards and criteria for solar energy systems, subsystems and components is one of the key objectives identified in the Department of Energy National Program for Solar Heating and Cooling of Buildings. This paper briefly describes various standards needs, planning efforts and some of the current activities which are underway relating to passive solar standards, performance criteria and code provisions.

21120. Goldman, D. T. The metric system: Its status and future, *IEEE Spectrum* 18, No. 4, 60-63 (Apr. 1982).



Key words: economic benefits; industry; International System of Units (SI); metric system; status and future.

- 21121.** Cooper, L. Y. *Measuring the leakage of door assemblies during standard fire exposures*, *Fire Mater.* 5, No. 4, 163-174 (1981).

Key words: building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods.

The results of applying the tentative, high temperature, International Standards Organization test method DP 5925 Part 3, which was developed to measure smoke leakage of door assemblies during the course of a standard fire endurance test, are reported. A critical analysis reveals that the basic objective of the test method is limited in its utility in that fire scenarios in high-rise buildings may not be adequately simulated. Independent of this limitation, the analysis then identifies certain theoretical problems with the test method and its procedures. These lead to a conclusion that the test method is not generally reliable. An alternative test concept which appears to remove this limitation and all of its problems is described, and its development is advocated.

- 21122.** Simon, T.; Linsky, J. L.; Stencel, R. E. *On the reality of a boundary in the H-R diagram between late-type stars with and without high temperature outer atmospheres*, *Astrophys. J.* 257, No. 1, 225-246 (June 1, 1982).

Key words: late-type stars; stellar atmospheres; stellar chromospheres; stellar coronae; ultraviolet spectra.

We test the hypothesis originally proposed by Linsky and Haisch that a boundary exists in the H-R diagram separating yellow giants ( $V-R \leq 0.80$ ), which typically show evidence of  $10^5$  K plasma in their outer atmospheres, from red giants and supergiants ( $V-R > 0.80$ ), which typically show little or no evidence of any plasma hotter than  $10^4$  K. We present and discuss *IUE* 1150-2000 Å low-resolution spectra of 39 late-type stars of luminosity classes I-IV. Our first test involves deeply exposed spectra of 10 stars chosen to constitute a "reverse bias" sample; that is, stars to the left (larger  $T_{\text{eff}}$ ) of the proposed boundary were chosen on the basis that they are likely to have the weakest magnetic fields and thus the smallest amounts of  $10^5$  K plasma for their effective temperatures, whereas stars to the right (smaller  $T_{\text{eff}}$ ) of the proposed boundary were selected on the basis that they are likely to have the strongest magnetic fields and thus the largest amounts of  $10^5$  K plasma for their effective temperatures. Despite this reverse bias, we observe weak C IV emission indicative of high-temperature plasma in four of the six stars to the left, but we detect no C IV emission in the four stars to the right.

In our second test using the entire sample of 39 stars, we find that nearly all of the yellow giants and supergiants have an emission feature at 1549 Å, which we attribute to C IV. However, among these 21 stars there is a range of nearly two orders of magnitude in  $f_{\text{C IV}}/I_{\text{bol}}$ . This large dispersion could be attributed to temporal or spatial variability, differing magnetic field strengths and geometries, or age-related effects during post-main-sequence evolution. Except for two spectroscopic binaries and one hybrid star, none of the 18 red giants and supergiants shows prominent C IV emission, and upper limits on  $f_{\text{C IV}}/I_{\text{bol}}$  are in many cases an order of magnitude smaller than the weakest detection among the 21 stars to the left. We therefore conclude that the Linsky-Haisch transition region boundary is a real phenomenon in the sense that single stars to the right of the boundary, with the exception of one hybrid K star, contain significantly less  $10^5$  K plasma compared with single stars to the left of the boundary. We speculate that a radiative instability may play an important role in the existence of such a boundary in the H-R diagram.

However, the appearance of He I  $\lambda 10830$  emission and absorption lines in stars to the right of the Linsky-Haisch boundary is puzzling because the apparent absence of any plasma hotter than  $10^4$  K in such stars argues against the usual population mechanisms of photoionization-recombination and collisional excitation for the  $2^3\text{S}$  level of neutral helium.

- 21123.** Walton, G. N. *Airflow and multi-room thermal analysis*, *ASHRAE Trans. Tech. Paper No. 2704*, 88, Pt. 2, 11 pages (1982).

Key words: building energy analysis; computer simulation; infiltration; natural ventilation.

A model for computing the infiltration and air flow between rooms of a multi-room building is presented in terms of basic principles of fluid mechanics. This model has been incorporated into a comprehensive loads-predicting computer program. Air flows, room temperatures, and heating loads for a typical townhouse under different conditions of environment and with various construction features are computed. These calculations show the feasibility of detailed multi-room air movement analysis. They also indicate that when the inter-room openings of low-rise structure are large compared to the envelope openings, the infiltration and total load can be accurately, and more quickly, computed by assuming no resistance to air flow between rooms. This property will also allow simplified calculations for high-rise buildings with many rooms. Methods are proposed for handling more complex air flow phenomena.

- 21124.** Fong, E.; Kimbleton, S. R. *Database semantic integrity for a network data manager*, *Proc. Natl. Computer Conf., 1980, Anaheim, CA, May 19-22, 1980*, pp. 261-288 (AFIPS Press, 1815 North Lynn Street, Arlington, VA 22209).

Key words: constraint; database; database management system; data correctness; integrity; networks; remote access of data; semantic integrity.

Data in a database represents an abstraction or model of a 'real world' application. Effective use of the database requires that the contained data accurately describe the application. The field of semantic integrity is concerned with assuring that data is logically correct. Semantic integrity promises to be of even greater importance in the context of networked databases since local database management is likely to want strong assurances that remote, and therefore, presumably less knowledgeable users, will not impact database integrity. This paper: i) categorizes semantic integrity features; ii) identifies an approach to maintaining integrity in accessing multiple, remote, heterogeneous DBMSs; and iii) describes an Experimental Semantic Integrity System (XSIS) now being designed and implemented at the National Bureau of Standards.

- 21125.** Fish, R. H.; Brinckman, F. E.; Jewett, K. L. *Fingerprinting inorganic arsenic and organoarsenic compounds in situ oil shale retort and process waters using a liquid chromatograph coupled with an atomic absorption spectrometer as a detector*, *Environ. Sci. Technol.* 16, No. 3, 174-179 (Mar. 1982).

Key words: arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; speciation.

Inorganic arsenic and organoarsenic compounds were speciated in seven oil shale retort and process waters, including samples from simulated, true, and modified in situ processes, by using a high-performance liquid chromatograph automatically coupled to a graphite furnace atomic absorption detector. The molecular forms of arsenic at ppm levels ( $\mu\text{g mL}^{-1}$ ) in these waters are identified for the first time and shown to include arsenate, methylarsonic acid, and phenylarsonic acid. An arsenic-specific fingerprint chromatogram of each retort or process water studied has significant implications regarding those arsenical species found and those marginally detected, such as dimethylarsinic acid and the suspected carcinogen arsenite. The method demonstrated suggests future means for quantifying environmental impacts of bioactive organometal species involved in oil shale retorting technology.

- 21126.** Harrison, S. A.; Gills, T. E.; Maienthal, E. J.; Rook, H. L.; Wise, S. A.; Zeisler, R. L.; Goldstein, G. M. *The National Environmental Specimen Bank pilot program*, *Proc. Symp. Trace Substances in Environmental Health XIV. 1980, Columbia, MO, June 10-12, 1980*, D. D. Hemphill, ed., pp. 329-340 (University of Missouri, Columbia, MO, 1980).

Key words: environment; human health; National Environmental Specimen Bank; specimen banking; storage evaluation and analysis.

In response to the increasing concern for the potential dangers to human health and the environment by the influx of man-made substances in our ecosystem, the U.S. EPA, in cooperation with the National Bureau of Standards (NBS), is currently studying the feasibility of establishing a National Environmental Specimen Bank. Recently, a 5 year pilot program was initiated at NBS to provide



experience in all phases of specimen banking, i.e., collection, storage evaluation and analysis. These activities have been implemented for the first sample included in this pilot study: human liver samples. This paper will describe the sampling protocol, homogenization procedure, storage evaluation and analytical techniques employed for these liver samples.

**21127.** Cummings, A. L.; Hocken, R. J. An accurate temperature-controlled polarimeter, *Precis. Eng.* 4, No. 1, 33-38 (Jan. 1982).

Key words: calibration; polarimetry; standards.

A photoelectric polarimeter has been constructed for the purposes of calibrating polarimetric standards and for redetermining the value for the specific rotation of sucrose in solution. The polarimeter has full circle rotation capability with sensitivity of 0.6 arc-sec (3  $\mu$ rad) and in specific measurements an estimated accuracy of  $\pm 2$  arc-sec at the 99% confidence level. The polarimeter uses both arc lamp and laser sources. Sample temperatures can be controlled to within  $\pm 0.5$  mK per day at, or around, 20°C, and six liquid, solid or gaseous samples may be simultaneously housed. Measurements of all six samples may be completed in a few minutes. In this paper we present the design details of this polarimetric system. The design required the careful application of high precision manufacturing techniques coupled closely with metrology throughout the manufacturing process.

**21128.** Damant, G. H.; Williams, S. S.; Krasny, J. F. Cigarette ignition behavior of commercial upholstery cover fabrics. *J. Consumer Product Flammability* 9, No. 1, 31-46 (Mar. 1982).

Key words: cigarettes; fabrics; flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; textiles; upholstered furniture.

The cigarette ignition of 70 primarily cellulosic upholstery cover fabrics was studied independently in two laboratories: the California Bureau of Home Furnishings (BHF) and the Center for Fire Research, National Bureau of Standards (NBS). BHF used the mini-mockup procedure, NBS tested the fabrics in mockups resembling the cushion and vertical members of actual furniture. BHF classified the fabrics according to self-extinguishment or the time to reach 10 or 20 percent weight loss during continued smoldering of the fabrics mounted over a variety of upholstery filling materials and exposed to a burning cigarette. NBS classified the fabrics according to self-extinguishment or ignition when the cigarettes were placed into crevices made up by a full size cushion and two types of filling materials in the vertical member, or on the flat surface of the cushion. Fabrics which did not ignite in the NBS mockups also generally self-extinguished in the BHF polyester batting and foam mini-mockups.

Certain fabric characteristics which may improve cigarette ignition resistance could be identified, such as low weight in cellulosic fabrics, adding of thermoplastic fibers to cellulosic fibers in medium to heavy weight fabrics, certain backcoatings, and removal of impurities from cellulosic fabrics which are found in raw cotton or as residues from finishing operations.

**21129.** Ferrick, J. H.; Rhyne, J. J.; Segnan, R. Bulk magnetization of dysprosium-scandium alloys, *J. Appl. Phys.* 53, No. 3, 2232-2234 (Mar. 1982).

Key words: antiferromagnetism; critical fields; ferromagnetism; rare earths; scandium alloys; spin glass.

Bulk magnetization measurements were made on Dy<sub>0.25</sub>Sc<sub>0.75</sub> and Dy<sub>0.75</sub>Sc<sub>0.25</sub> alloys. The Dy<sub>0.25</sub>Sc<sub>0.75</sub> alloy has the characteristics of a spin-glass material. The low-field magnetization exhibits a peak near 27 K when the sample is warmed after cooling in zero applied field. Cooling in the presence of a field destroys the peak and results in a nearly temperature-independent magnetization below the peak "spin-freezing" temperature. The Dy<sub>0.75</sub>Sc<sub>0.25</sub> alloy undergoes an antiferromagnetic transition at T<sub>N</sub>=118 K and remains in a spiral antiferromagnetic state down to below 4.2 K. Ferromagnetic ordering can be induced by an applied field. The critical field for this transition is 13.5 kOe just below T<sub>N</sub>, increases as temperature decreases in contrast to conventional behavior, and exhibits a sharp anomalous rise below 29 K.

**21130.** Kelley, E. F.; Hebner, R. E.; Forster, E. O.; Fitzpatrick, G. J.

Observations of pre- and post-breakdown events in polydimethylsiloxanes, (Proc. Conf. 1982 IEEE Int. Symp. Electrical Insulation, Philadelphia, PA, June 7-9, 1982), *IEEE Conf. Rec. No. 82CH1780-6-E1*, 255-258 (IEEE Service Center, Single Publications Sales Dept., 445 Hoes Lane, Piscataway, NJ, June 1982).

Key words: breakdown; electrical insulation; high voltage; liquids; partial discharge; polydimethylsiloxanes.

The effect of viscosity and rate of voltage application on the electrical breakdown process in four polydimethylsiloxane fluids has been investigated under non-uniform field conditions using a high-speed image converter camera. The viscosity of these fluids ranged from 10 to 10,000 cSt, and the rate of rise of the approximately trapezoidal voltage pulse varied from 10 to 42 kV/ $\mu$ s. It was noted that, within experimental error, viscosity had no effect on the breakdown process. When the cathode was a point, pre-breakdown streamer propagation was shown to be related to the rate of rise of the applied voltage and the breakdown voltage was highest for the highest rate. When the anode was a point, the streamer propagation was approximately independent of applied voltage. The time to cross the gap of 3 mm was determined to be  $0.6 \pm 0.1$   $\mu$ s independent of the fluid's viscosity. The implications of those findings are discussed in the light of existing theories.

**21131.** Lynn, J. W. Neutron scattering studies of ternary magnetic superconductors, *Proc. Conf. Ternary Superconductors, Lake Geneva, WI, Sept. 24-26, 1980*, Shenoy, Dunlap, and Fradkin, eds., pp. 51-57 (Elsevier North Holland, Inc., New York, NY, 1981).

Key words: antiferromagnetic superconductors; chevrel-phase; ErRh<sub>4</sub>B<sub>4</sub>; ferromagnetic superconductors; neutron scattering; ternary superconductors.

The rare-earth (RE) ternary superconductors belonging to the REMo<sub>2</sub>X<sub>8</sub> (X=S,Se) and ERh<sub>4</sub>B<sub>4</sub> classes of materials have provided the first unambiguous realizations in nature of the coexistence of superconductivity and long range magnetic order. The competitive nature of these two cooperative phenomena is illustrated by the ferromagnetic compounds HoMo<sub>2</sub>S<sub>8</sub> and ErRh<sub>4</sub>B<sub>4</sub>, which first become superconducting and then order magnetically at lower temperatures. At first the superconductivity is able to prevent ferromagnetic alignment and a compromise long-wavelength oscillatory magnetization is established at intermediate temperatures. At sufficiently low temperatures, however, the superconductivity is destroyed as ferromagnetism sets in. Antiferromagnetic order, on the other hand, is found to be much less detrimental to superconductivity and there are now a rather large number of ternary materials where antiferromagnetism coexists with superconductivity. Inelastic scattering studies have shown that the crystal field splittings of the rare-earth ions in these materials are generally large in comparison with the magnetic energies.

**21132.** Mallard, W. G.; Miller, J. H.; Smyth, K. C. Resonantly enhanced two-photon photoionization of NO in an atmospheric flame, *J. Chem. Phys.* 76, No. 7, 3483-3492 (Apr. 1, 1982).

Key words: energy transfer; flames; ionization; multiphoton; optogalvanic; two photons.

Molecular multiphoton ionization experiments are reported for the first time in a flame environment. The resonantly enhanced two-photon photoionization spectrum of NO from 270 to 317 nm in an atmospheric pressure H<sub>2</sub>/air/N<sub>2</sub>O flame is essentially identical with respect to both line position and intensity to that which is predicted for the one-photon absorption to the intermediate A state. A model is developed here which accounts for this result by including rates for collisional repopulation of the laser depleted state. Based on this model, the rotational transfer rate constant for NO is estimated to be  $\geq 4 \times 10^9$  s<sup>-1</sup> in the flame, corresponding to a cross section of  $\sim 70$  Å<sup>2</sup>. It is found that the photoionization spectra obtained in this work have far better signal-to-noise and resolution than those reported for NO in flames using laser-induced fluorescence methods and that the estimated detection limit for NO is 1 ppm.

**21133.** Stockbauer, R.; Bertel, E.; Madey, T. E. The origin of H<sup>+</sup> in electron stimulated desorption of condensed CH<sub>3</sub>OH, *J. Chem. Phys.* 76, No. 11, 5639-5641 (June 1, 1982).



Key words: deuterium; electron stimulated desorption; ESD; ion kinetic energy distribution; methanol; methanol-d; methanol-d<sub>3</sub>.

Using deuterium labelling (CH<sub>3</sub>OD and CD<sub>3</sub>OH) it was determined that H<sup>+</sup> in electron stimulated desorption (ESD) from condensed methanol multilayers is removed from the carbon rather than the oxygen atom. The peak in the ion kinetic energy distributions shifted toward lower energy as the energy of the incident electron was lowered consistent with the Franck-Condon model of ESD. The effects of hydrogen bonding on the desorbed ion mass spectra are discussed.

21134. Waksman, D.; Walton, W. D. Fire testing of solar collectors by ASTM E 108, *Fire Technol.* 18, No. 2, 174-187 (May 1982).

Key words: fire tests; roofing fire resistance; roofing fire tests; solar collectors.

A study was undertaken to investigate the use of ASTM E 108 (NFPA 256, UL 790), Fire Tests of Roof Coverings, for testing roof-mounted solar energy collectors. Data are presented showing the results of the testing conducted. An evaluation of the testing procedures as they apply to roof-mounted solar collectors is given.

21135. Wasson, O. A.; Meier, M. M.; Duvall, K. C. Absolute measurement of the uranium-235 fission cross section from 0.2 to 1.2 MeV, *Nucl. Sci. Eng.* 81, 196-212 (1982).

Key words: absolute fission cross section; neutron detector; neutron flux monitor; neutron standards; U-235 fission cross section.

The absolute <sup>235</sup>U neutron-induced fission cross section has been measured at the U.S. National Bureau of Standards (NBS) 3-MV Van de Graaff Laboratory from 0.2- to 1.2-MeV neutron energy. The mass of the <sup>235</sup>U contained in a large volume multiplicated fission ionization chamber was measured relative to the NBS fissionable isotope mass standards. Pulsed beam time-of-flight techniques were used with neutrons from the <sup>7</sup>Li(p,n)<sup>7</sup>Be reaction while the neutron flux was monitored with a large plastic scintillator whose efficiency was both calculated and measured with the associated-particle technique. The cross sections, which were measured with a typical uncertainty of 2.3%, are ~2% lower than the ENDF/B-V evaluation.

21136. Wlodawer, A.; Hendrickson, W. A. A procedure for joint refinement of macromolecular structures with X-ray and neutron diffraction data from single crystals, *Acta Crystallogr.* A38, 239-247 (1982).

Key words: joint refinement; macromolecular structures; neutron; restrained refinement; single crystals; x rays.

A procedure is presented for the stereochemically restrained least-squares refinement of macromolecular structures with neutron and X-ray diffraction data from single crystals. This procedure has been tested by refining a model of ribonuclease A using neutron data to minimal spacings of 2.8 Å and X-ray data from within 2.0 Å spacings. Joint X-ray and neutron refinement is well conditioned and tends to avoid false minima that may occur when a medium-resolution structure is refined solely with the neutron structure factors.

21137. Wlodawer, A.; Sjölin, L. Hydrogen exchange in RNase A: Neutron diffraction study, *Proc. Natl. Acad. Sci.* 79, 1418-1422 (Mar. 1982).

Key words: amide protection; flexibility; hydrogen exchange; protein structure; refinement; ribonuclease.

Hydrogen exchange has been studied in a single crystal of RNase A [ribonuclease (pancreatic), EC 3.1.27.5] in the course of a neutron structure investigation. Refinement of the occupancies of amide hydrogens provided information about the kind of isotope present in each site and also provided estimates of the errors associated with the measurement. Twenty-eight of the 120 peptide amide hydrogens were found to be at least partially protected from exchange during approximately 1 year required for crystal preparation and data collection. Most of the protected hydrogens were involved in hydrogen bonds with main-chain carbonyl groups. A contiguous region of the β-sheet containing residues 75, 106-109, 116, and 118 had a large number of protected hydrogens, indicating its low flexibility and the lack of accessibility to solvent. Residues 11-13 from

the α-helix near the amino terminus were protected, in good agreement with a model of cooperative unwinding of this helix, starting from the free (amino) end.

21138. Guttman, C. M.; DiMarzio, E. A. Rotational isomeric modeling of a polyethylene-like polymer between two plates: Connection to "gambler's ruin" problem, *Macromolecules* 15, No. 2, 525-531 (Mar.-Apr. 1982).

Key words: gambler's ruin problem; Monte Carlo; polyethylene; polymer; polymer between two plates; rotational isomeric state model; switchboard model.

A Monte Carlo simulation of a polyethylene-like polymer chain between two plates has been performed. This continuum treatment augments previous analytical lattice treatments of completely flexible chains between plates. The Monte Carlo results show that the simple concept of statistical length appropriate to unconfined bulk polymer is also appropriate to chain portions residing in the amorphous regions of lamellar semicrystalline polymer. Thus, the "gambler's ruin" method, with the statistical length of the polymer used as the fundamental step length, is a valid method to obtain quantitative estimates of quantities such as length of loops, length of ties, and fraction of loops or ties for moderately stiff polymers. Previous estimates of the amount of chain folding in polyethylene are thus shown to retain their validity for the more realistic isomeric state model.

21139. Gross, D. A progress report on international standardization of fire tests of building materials and structures, *Fire J.* 73, No. 2, 79-82, 90 (Mar. 1982).

Key words: ASTM; building materials; fire resistance; fire tests; international; ISO; standards; Technical Advisory Group.

A brief history is provided of the formation and growth of ISO Technical Committee 92 on Fire Tests of Building Materials and Constructions. Present and future standards and Working Group activities are described. Comparisons are made between national, international and regional standardization activities dealing with fire tests.

21140. Anderson, W. E.; Ramboz, J. D.; Ondrejka, A. R. The detection of incipient faults in transmission cables using time domain reflectometry techniques: Technical challenges, *IEEE Trans. Power Appar. Syst.* PAS-101, No. 7, 1928-1934 (July 1982).

Key words: aging; dielectric; distribution; electrical failure; polyethylene; reflectometry; rf characteristics; transmission; treeing.

The location and repair of faults in underground transmission lines is a difficult and time-consuming operation. The Department of Energy has sponsored research in the development of instrumentation to detect and locate incipient fault sites. Some of these methods rely on reflectometry techniques in either the time or frequency domain. NBS has investigated the feasibility of using such methods in extruded polyethylene cables.

21141. Kusuda, T.; Alereza, T.; Hovander, L. Development of equipment seasonal performance models for simplified energy analysis methods, *ASHRAE Trans. Tech. Paper No. 2715*, 82, Pt. 2, 13 pages (1982).

Key words: air conditioner; energy analysis; equipment performance; gas furnace; heat pump; simplified calculation.

In pursuit of development of simplified energy calculation methodologies, seasonal performance models for residential heating and cooling systems were developed. Previous studies have shown that the variable-base degree-day (VBDD) method renders results close to those generated by hourly models, such as DOE-2. However, the results included only heating and cooling loads, not the energy use. The objective of this research was to develop a method for calculation of seasonal performance of residential HVAC equipment while it could be used within the framework of variable-base degree-day method.

Using the results of DOE-2 on 60 residences representing 10 climatological conditions, seasonal performance models were developed for gas and oil furnaces, air conditioners, and heat pumps.



These models utilize the heating and cooling loads calculated by VBDD, equipment specifications, and weather information, to calculate the seasonal efficiencies/COP's for residential HVAC equipment. Results obtained using these seasonal models were mainly within 5 percent of those calculated hourly by DOE-2.

- 21142.** Lippiatt, B. C.; Weber, S. F. Water rates and residential water conservation, *J. AWWA* 74, No. 6, 278-281 (June 1982).

Key words: average price; economic analysis; marginal price; water conservation; water pricing; water rate schedules.

Descriptions of the five major types of water rate schedules are presented. A national sample of rate schedules is analyzed to measure the effect of existing water pricing policies on the dollar value to homeowners of a unit of conserved water. This value is found to be significantly lower than the average price of water, which analysts often incorrectly use to evaluate water conservation investments.

- 21143.** Carver, G. P.; Buehler, M. G. An analytical expression for the evaluation of leakage current in the integrated gated-diode electrometer, *IEEE Trans. Electron Devices* ED-27, No. 12, 2245-2252 (Dec. 1980).

Key words: electrical test structure; gated diode; generation lifetime; integrated gated-diode electrometer; integrated test structure; leakage current; open-circuit voltage decay; surface recombination velocity.

The integrated gated-diode electrometer microelectronic test structure permits automated measurement of leakage currents in p-n junctions. The test method incorporates on-chip signal processing using an electrometer amplifier. An analysis of the equivalent circuit, which includes the effects of loading by the electrometer, yields the working equations required for the interpretation of the measurements and the determination of the generation lifetime and surface-recombination velocity. In certain situations, the generation lifetime can be determined independently of the diode area, allowing the device size to be scaled down without sacrificing the signal amplitude.

- 21144.** Phillips, W. E. Improved thermometry for deep-level measurements, *J. Phys. E: Sci. Instrum.* 15, 499-501 (1982).

Key words: deep level measurements; measurement methods; semiconductor materials characterization; semiconductors; thermally stimulated measurements; thermometry.

The various semiconductor deep-level measurement techniques are often limited in their precision by thermometry. A temperature-measurement procedure is described which uses a statistical calibration of forward-biased temperature-sensing diodes to achieve a two-sigma precision of  $\pm 8$  mK. Several applications are discussed to illustrate where the improved thermometry can significantly affect the quality of the results.

- 21145.** Koenig, J. A. New program to help identify technical barriers to trade, *Stand. Eng.* 34, No. 3, 55-56, 70 (June 1982).

Key words: foreign regulations; GATT; notification program; standards code; trade.

This article describes a new program established as a result of the Multilateral Trade Negotiation (MTN) Agreement on Technical Barriers to Trade, which was implemented in the United States by Title IV of the Trade Agreements Act of 1979. Under the MTN Agreement (popularly known as the Standards Code) signatory countries are required to notify other signatories of proposed central government mandatory standards that might significantly affect trade. The National Bureau of Standards' procedures for making the required U.S. notifications and disseminating information on notices received from other countries are detailed.

- 21146.** Stahlbush, R. E.; Forman, R. A. Vibronic spectrum of the  $U_2$  isoelectronic center in Si:In, *J. Lumin.* 26, 227-232 (1982).

Key words: bound exciton; density of states; indium doped silicon; isoelectronic; optical properties; photoluminescence; silicon.

The photoluminescence spectrum of Si:In measured at 2 and 4 K

using samples from several suppliers has been found to be preparation sensitive. In particular, intensity variations allow us to distinguish a sharp no-phonon line at 1.118 eV, variously referred to as  $U_2$  or P, and its associated vibronic spectrum from the In(NP) lines and their phonon replicas. Whereas the intensity of the latter did not show preparation sensitivity, the former has been observed to change by three orders of magnitude. The  $U_2$  vibronics form a broad-structured spectrum containing density-of-states features. The appearance of phonons other than those conserving crystal momentum demonstrates the exciton is bound to a low symmetry site. In addition, the spectrum includes a peak at 1.109 eV, called R, and a shoulder at 1.107 eV which involves too small an energy loss to be density-of-states related, and these features are most likely modes of the  $U_2$  impurity complex. This complex has been tentatively identified as an isoelectronic center composed of an indium-phosphorus nearest-neighbor substitutional pair.

- 21147.** Hummer, D. G. The effect of reflected and external radiation on stellar flux distributions, *Astrophys. J.* 257, No. 2, 724-732 (June 15, 1982).

Key words: radiative transfer; stars, atmospheres; stars, circumstellar shells; stars, winds.

The effect of radiation emitted or scattered by circumstellar material, such as a stellar wind, into the stellar photosphere is investigated on the basis of a gray model atmosphere generalized to include the effects of an external radiation field and a surface boundary condition describing the reflection of a specified fraction, depending on the frequency, of the outgoing radiation. Substantial modifications both to the temperature and flux distributions are found.

- 21148.** Hummer, D. G. High order asymptotic expansions of the four kernel functions for line formation with the Voigt profile, *J. Quant. Spectrosc. Radiat. Transfer* 27, No. 6, 569-573 (1982).

Key words: lineshape; radiative transfer; spectral line formation; stellar atmospheres; Voigt function.

Analytical expressions are given for the coefficients, as a function of the Voigt parameter  $a$ , in the asymptotic expansions of the kernel functions  $K_1(\tau)$ ,  $K_2(\tau)$ ,  $M_1(\tau)$ , and  $M_2(\tau)$  that describe the transfer of radiation scattered with complete redistribution over a Voigt profile.

- 21149.** Janev, R. K.; Belic, D. S. Double resonant charge exchange in ion-ion collisions, *Phys. Lett.* 89A, No. 4, 190-192 (May 10, 1982).

Key words: double resonant charge exchange; ion-ion collision processes; multicharged ions theoretical.

The process of resonant double charge exchange in low energy ion-ion collisions is considered. The effects of the Coulomb interaction of the nuclei are taken into account. Cross section calculations are performed both for completely and partially stripped projectile ions with  $3 < Z < 10$ .

- 21150.** Carino, N. J.; Lew, H. S. Re-examination of the relation between splitting tensile and compressive strength of normal weight concrete, *ACI J. Tech. Pap., Title No. 79-23*, 214-219 (May-June 1982).

Key words: age-strength relation; building codes; compressive strength; concretes; regression analysis; safety; shear properties; splitting tensile strength; statistical analysis.

Based on statistical analyses of selected data, which included concretes with compressive strengths from 980 psi (6.9 MPa) to 5750 psi (39.7 MPa), it is shown that the commonly assumed square root of compressive strength function is not the most appropriate relation for selected data or data with a similar precision and the same range; rather, a simple power function is more applicable over a wide range of concrete strengths.

- 21151.** Gadzuk, J. W.; Doniach, S. A soluble relaxation model for core level spectroscopy on adsorbed atoms, *Surf. Sci.* 77, 427-448 (1978).

Key words: adsorption; many-body theory; photoemission; relaxation.

The photoelectron spectrum of core levels in adsorbed atoms is



calculated taking into account the screening of the core hole due to both displaced surface plasmons (image charges) and actual transfer of screening charge into the lowest unfilled valence levels of the adsorbate. The theory is detailed on a simplified but exactly soluble model, permitting parametric numerical studies of the spectrum while maintaining close contact with physical understanding. Recent theory on adsorbate relaxation effects due to Gumhalter and Newns, Gunnarsson and Schönhammer, Lang and Williams, and others are considered in the light of this model.

- 21152.** Gadzuk, J. W. Exactly soluble x-ray-edge model for nonadiabatic scattering from metal surfaces, *Phys. Rev. B* **24**, No. 4, 1866-1871 (Aug. 15, 1981).

Key words: inelastic scattering; sticking; surface processes; x-ray edge.

One implication of the Anderson orthogonality theorem is that a particle cannot elastically scatter from a metallic surface with unit probability. A simple, but exactly soluble, model (within the usual bounds of x-ray edgeology) is presented which enables transparent and analytic calculation of the no-loss line intensity. Comparison between the dynamic properties of the scattering event and the static properties of the coupled substrate-particle system are made. Commentary on this result, in the light of other recent work, is offered.

- 21153.** Poliakoff, E. D.; Dehmer, P. M.; Dehmer, J. L. Photoelectron-photoion coincidence spectroscopy of gas-phase clusters, *J. Chem. Phys.* **76**, No. 11, 5214-5224 (June 1, 1982).

Key words: clusters; coincidence; mass spectrometry; photoelectron spectroscopy; photoionization; Xe.

A photoelectron-photoion coincidence technique for obtaining the photoelectron spectrum of a single component of a gas-phase mixture has been developed. It utilizes a newly designed instrument which measures the ion mass in coincidence with the photoelectron kinetic energy. Initial experiments were carried out on Xe<sub>2</sub> and Xe<sub>3</sub> produced in mixture of clusters (plus monomer) in a free-jet supersonic expansion. These measurements determined the photoelectron appearance potential (i.e., the lowest binding energy for which photoelectrons are detected) to be 11.30(5) eV for Xe<sub>3</sub>. It was also found that fragmentation of cluster ions strongly affects the coincidence spectra. This was investigated by varying the stagnation pressure, and thus the beam composition, in order to assess fragmentation contributions to coincidence spectra of the cluster under study. One case studied in detail indicated the energy levels of Xe<sub>3</sub> near the ionization potential of 11.6 eV, corresponding to 0.7 eV of internal energy in Xe<sub>3</sub><sup>+</sup>, fragmented to form Xe<sub>2</sub><sup>+</sup> and Xe.

- 21154.** Grunze, M.; Dowben, P. A. A review of halocarbon and halogen adsorption with particular reference to iron surfaces, *Appl. Surf. Sci.* **10**, 209-239 (1982).

Key words: adsorption; chemisorption; dissociation; halocarbon; halogen; iron.

In this communication, a comprehensive review on halocarbon adsorption on solid surfaces is presented. The physical and chemical properties of surfaces, for which adsorbed halocarbons readily dissociate, are dominated by the respective halogens; hence, the published data on halogen adsorption on surfaces are also presented in a tabulated form. A complete reference list on halogen overlayers is provided. The adsorption of halocarbons is discussed with reference to their surface chemistry while technological as well as some environmental aspects are also mentioned. The available results are discussed according to the substrate surfaces used. In general, one can distinguish between substrates where some halocarbons adsorb molecularly or with partial fragmentation and those surfaces where the halocarbons dissociate completely and the atomic fragments remain adsorbed or absorb in the selvedge. The former class of substrates includes those which catalyze elimination reactions in the adsorbed phase (e.g., platinum). The latter case has been observed for iron surfaces, where after CFCI<sub>3</sub> adsorption, a pronounced effect on the geometry and stability of the surface layer composed of chlorine atoms by the absorbed fragments (i.e., carbon and fluorine) has been noted. This vertical interaction of the coadsorbed (adsorbed) atomic species in the selvedge is more pronounced than the effect of the lateral interaction in the adsorbed layer and might be of general

importance in more complicated adsorption systems. We cannot offer an explanation for the physical basis of these vertical interaction effects, but these effects clearly demonstrate that, in certain systems, a separation between surface and solid state chemistry is arbitrary.

- 21155.** Mopsik, F. I.; DeReggi, A. S. Numerical evaluation of the dielectric polarization distribution from thermal-pulse data, *J. Appl. Phys.* **53**, No. 6, 4333-4339 (June 1982).

Key words: charge distribution; computer analysis; data reduction; Fourier analysis; piezoelectric polymers; polarization distribution; thermal pulse experiment.

A method for numerically carrying out the Fourier analysis for the thermal-pulse experiment is given. It is shown that it is possible to obtain the polarization distribution across the thickness of a thin film (25 μm) to within the limits set by the experimental data. For such films, resolution of the distribution to within 0.1 of the film thickness is possible. Results are given for the experiment by using a charge measurement rather than a voltage measurement. The effect of a finite-width pulse is shown to cut off the Fourier coefficients in such a way as to smooth any distribution. Pulsing the sample alternately on both sides is shown to greatly increase the resolution of the experiment. Results for a PVF<sub>2</sub> film and a P(VF<sub>2</sub>-TFE) copolymer film show that interesting details can be found by the experiment.

- 21156.** Paffenbarger, G. C.; Rupp, N. W.; Patel, P. R. Copper-free amalgams: Dimensional change after approximately five years at 60, 37, and 23°C, *J. Dent. Res.* **61**, No. 6, 811-813 (June 1982).

Key words: alloy; amalgam; dental; dimensional change; expansion.

Two copper-free amalgams expanded excessively after storage in air at 60°C for about five yr. One expanded significantly at 37°C and slightly at 23°C. High silver content, absence of copper, and presence of small amounts of zinc, or all three, seemed to promote very high expansions at 60°C.

- 21157.** Santoro, A.; Roth, R. S.; Austin, M. Powder neutron diffraction study of the nonstoichiometric solid solution of lithium tantalate 9LiTaO<sub>3</sub>:Ta<sub>2</sub>O<sub>5</sub>, *Acta Crystallogr.* **B38**, 1094-1098 (1982).

Key words: lithium tantalate; neutron diffraction; powder method; Rietveld method; solid solution; tantalum oxide.

The nonstoichiometric solid solution 9LiTaO<sub>3</sub>:Ta<sub>2</sub>O<sub>5</sub> has been studied with the powder neutron diffraction technique, and the intensity data have been used to refine several structural models with the Rietveld method. The results of these calculations show that the best fit to the experimental observations is obtained with the model for the defective structure proposed by Nassau & Lines [*J. Appl. Phys.* (1970), **41**, 533-537] ( $R_n=4.37$ ,  $R_p=6.91$ ,  $R_w=9.34$ ,  $R_e=5.58$  for 2964 observations). Data have also been collected from stoichiometric LiTaO<sub>3</sub>, and the results of the refinement of this structure ( $R_n=3.64$ ,  $R_p=6.97$ ,  $R_w=9.70$ ,  $R_e=5.63$  for 2725 observations) agree well with those obtained with single-crystal diffraction techniques.

- 21158.** Hoffman, J. D. Role of reptation in the rate of crystallization of polyethylene fractions from the melt, *Polymer* **23**, 656-670 (May 1982).

Key words: crystallization; fraction; friction coefficient; growth rate; polyethylene; régime I; régime II; reptation.

The theory of polymer crystallization with chain folding is extended to include the effect of reptation in the melt on the rates of crystallization  $G_I$  and  $G_{II}$  in régimes I and II. The result is that the pre-exponential factors for  $G_I$  and  $G_{II}$  contain a factor  $1/n$ , where  $n$  is the number of monomer units in the pendant chain being reeled onto the substrate by the force of crystallization;  $n$  is proportional to the molecular weight. The predicted fall in growth rate with increasing molecular weight is found experimentally in nine polyethylene fractions  $M_z=2.65 \times 10^4$  to  $M_z=2.04 \times 10^5$ , corresponding to  $n_z=1.90 \times 10^3$  to  $1.45 \times 10^4$ . The data on these fractions are analysed to find the reptation or 'reeling' rate  $r$  and the substrate completion rate  $g$ . The values  $g_{nuc} \sim 0.5/n_z$  cm s<sup>-1</sup> and  $r_{nuc} \sim 21/n_z$  cm s<sup>-1</sup> at 400 K are obtained from the data in conjunction with nucleation theory adapted to account for reptation assuming a substantial degree of regular folding. These results are consistent with a melting point in the range



of  $\sim 142^\circ$  to  $\sim 145^\circ\text{C}$ . (The analysis using  $T_m(\infty) = 145^\circ\text{C}$  gives values of such quantities as  $\sigma$ ,  $\sigma_e$ , and  $\alpha$  that are quite similar to those deduced in earlier studies.) An estimate of  $g$  (denoted  $g_{\text{exp}}$ ) that is independent of the molecular details of nucleation theory gives  $g_{\text{exp}} \sim 0.4/n_z \text{ cm s}^{-1}$  and  $r \sim 17/n_z \text{ cm s}^{-1}$  at 400 K. Calculations of the reptation rate from  $r_{1,2} = (\text{force of crystallization} \div \text{friction coefficient for reptation in melt})$ , where the friction coefficient is determined from diffusion data on polyethylene melts, leads to  $r_{1,2} \sim 17/n_z$  to  $34/n_z \text{ cm s}^{-1}$  at 400 K, or  $g_{1,2} \sim 0.4/n_z$  to  $0.8/n_z \text{ cm s}^{-1}$ . The conclusion is that the reptation rate characteristic of the melt is fast enough to allow a significant degree of adjacent re-entry or 'regular' folding during substrate completion at the temperature cited, and that the substrate completion process is governed jointly by the activation energy for reptation  $Q_B^*$  and the work of chain folding  $q$ . The nucleation theory and the friction coefficient theory approaches are compared, and the formulations found to be essentially equivalent; the 'reeling' rate  $r$  is found to be proportional to  $(1/n)A_0(\Delta f)v_0 \exp[-(Q_B^* + q)/RT]$ , where  $v_0$  is a frequency factor, and  $A_0(\Delta f)$  is the force of crystallization on the pendant chain. The data analysis on the fractions confirms the detailed applicability of régime theory. The growth rate theory presented allows the possibility that the growth front may be microfaceted in régime I.

**21159.** Guttman, C. M.; DiMarzio, E. A.; Hoffman, J. D. **Modelling the amorphous phase and the fold surface of a semicrystalline polymer—The Gambler's Ruin method**, *Polymer* **22**, 1466-1479 (Nov. 1981).

Key words: amorphous phase; crystal-amorphous interface; fold surface; loops; polymer; semicrystalline polymer; tie molecules.

A semicrystalline polymer with lamellar morphology consists of alternating amorphous and crystalline regions. If sufficiently long, each molecule in this system traverses both the crystalline and amorphous zones. The amorphous portion is comprised of portions of a molecule that form loops that re-enter the same lamella at some distance from the point of emergence, and bridges that form connections between two different crystal lamellae. (A tight fold is not considered to be a loop). The statistics of loops and bridges are shown to be identical to the classical Gambler's Ruin problem in mathematical statistics. This is a useful observation because the extensive existing literature on the Gambler's Ruin problem allows us immediately to transcribe results to the polymer system. Using this approach, the ratio of the number of loops to the number of bridges is determined to be  $M$ , the thickness of the amorphous zone in unit statistical steps. Also, the average number of steps comprising the amorphous run is determined to be  $3M + 1$  for a simple cubic lattice in three dimensions. This modelling leads to a calculation of the minimal fraction of crystal stems involved in tight folding in a semicrystalline polymer. For a simple cubic lattice this is found to be  $2/3$ . The effects of crystal structure and stiffness of the chain in the melt on this bound are discussed.

**21160.** Guttman, C. M.; DiMarzio, E. A.; Hoffman, J. D. **Calculation of SANS intensity for polyethylene: Effect of varying fold planes and fold plane roughening**, *Polymer* **22**, 597-608 (May 1981).

Key words: adjacent reentry; fold plane roughening; melt crystallization; polyethylene; polyethylene fold planes; polymer; polymer crystallization; SANS; semicrystalline polymer.

The intensity of the small angle neutron scattering (SANS) for polyethylene crystallized in the lamellar habit from the melt at large supercoolings is calculated for  $\mu = 0.01$  to  $\mu = 0.14$  [ $\mu = (4\pi/\lambda) \sin(\theta/2)$ ]. Computations are made on models which allow various amounts and types of chain folding and varying degrees of 'tight' or 'regular' folds. The models that fit the SANS data best have folding along lattice planes in which the stem separation is larger than 0.5 nm (5 Å) or which allow for fold plane roughening on a variety of fold planes. The 'leapfrog' type folds mentioned by Sadler were also considered, and a possible cause for their existence suggested. As an example, the variable cluster model gives a good account of the SANS data with the surface roughening suggested by nucleation theory with fold planes [110], [200], and [310], or a mixture. Even though the conditions of crystallization used in preparing the SANS specimens (large supercoolings) were conducive to the maximum surface disorder, the probability of 'tight' or 'regular' folding,  $p_f$ , was found to be  $\sim 0.7$  for the best models. This corresponds closely to the theoretical lower bound  $p_f = 2/3$  which is rigorous for the case of

non-tiled stems. The probability of strictly adjacent re-entry in a single specified fold plane,  $p_{\text{adj}}$ , was  $\sim 0.4$  to  $\sim 0.7$  depending on the particular model chosen. The best models fit not only the SANS data, but also the liquid and crystal density, degree of crystallinity, and characteristic ratio (or radius of gyration). None of the models show the density anomaly inherent in the switchboard or random re-entry models of Yoon and Flory.

**21161.** Guttman, C. M.; Hoffman, J. D.; DiMarzio, E. A. **Monte Carlo calculation of SANS for various models of semicrystalline polyethylene**, *Faraday Discuss. Chem. Soc.* **68**, 297-309 (1979).

Key words: adjacent reentry model of crystal and amorphous phase in polymer; polymer; semicrystalline polymer; small angle neutron scattering; switchboard model of polymer surface.

Small-angle neutron scattering (SANS) of semicrystalline polyethylene is computed using a Monte Carlo technique similar to that used by Yoon and Flory. Models of polymer chains with substantial amounts of chain folding (with a probability of adjacent re-entry of 0.6–0.8) are shown to give the following: (1) proper density in the crystalline and amorphous regions, (2) the experimentally obtained radius of gyration, (3) scattering close to the experimentally obtained scattering. While SANS alone cannot decisively distinguish between the Yoon and Flory "switchboard" model and models with folds, present indications are that only models with a substantial amount of folding satisfactorily meet all conditions (1)–(3). The "switchboard" model used by Yoon and Flory to explain the SANS of semicrystalline polyethylene is shown not to meet criterion (1) above.

**21162.** Bloch, D.; Raj, R. K.; Snyder, J. J.; Ducloy, M. **Heterodyne detection of phase-conjugate emission in an Ar discharge with a low-power c.w. laser**, *J. Phys. Lett.* **42**, No. 2, L-31–L-34 (Jan. 15, 1981).

Key words: argon; laser spectroscopy; nonlinear spectroscopy; phase conjugation.

We report the observation of nearly degenerate four-wave mixing in Ar gas discharges at 867 nm (transition  $1s_3-2p_7$ ) using a low power c.w. laser. The weak phase-conjugate emission has been observed by means of a heterodyne detection technique at 30 MHz. This experimental scheme should be able to yield ultimate shot-noise limited signals, and thus could be used as a sensitive tool for phase-conjugation studies.

**21163.** Mahaffey, C. T. **An international performance-based standard method of developing national product specification standards**, *Proc. Int. Standardization—Testing, Certification and Related Matters, and Their Implications Under Trade Agreements Act of 1979*, U.S. Dept. of Commerce, Washington, DC, Oct. 15-16, 1980, pp. 1-6 (U.S. Government Printing Office, Washington, DC 20402).

Key words: international standards; international test methods; national product standards; performance standards.

This paper describes and proposes international consideration of a method that coordinates the international and national application of the ISO concept of 3 levels of standards. These 3 levels, intended to establish a technically-based hierarchy among standards, are defined by ISO as follows: a. Level 1—Fundamental Standards. General principles and fundamental standards for buildings and civil engineering structures; b. Level 2—Wide Ranging Standards. Standards for groups of products concerning preferred dimensions, performance requirements, general test methods, etc.; c. Level 3—Specific Standards. Descriptive standards for specific building products, materials or components concerning properties, test method, etc.

This proposed method pertains directly to the development and use of wide ranging ISO level 2 performance standards and related test methods—for products grouped according to their intended end-uses—in the subsequent development of national, level 3 specification standard, for each alternative nationally-manufactured product within such end use groupings.

**21164.** Eby, R. K. **Disorders in the crystal structures of homo- and copolymers of polytetrafluoroethylene**, *Proc. Int. Union Pure and Appl. Chem.—28th Macromolecular Symp., University of Massachusetts, Amherst, MA, July 13, 1982*, p. 592 (IUPAC, University of Massachusetts, Amherst, MA 01003).



Key words: copolymers; crystal; hexafluoropropylene; polytetrafluoroethylene; tetrafluoroethylene; x-ray diffraction.

The phase diagram of polytetrafluoroethylene and some copolymers of tetrafluoroethylene with hexafluoropropylene exhibits four solid crystal phases (1). The effect of comonomer units on these have been investigated by x-ray diffraction techniques.

21165. Birnbaum, G. Far infrared spectra of  $H_2$  and mixtures of  $H_2$ - $CH_4$  and  $H_2$ -He, *Proc. NASA Workshop Vibrational-Rotational Spectroscopy for Planetary Atmospheres, Annapolis, MD, Mar. 17-19, 1980*, 23 pages (1980).

Key words: absorption coefficient; collision-induced; far infrared spectra; hydrogen; hydrogen mixtures; rotational transitions; spectra.

This report presents some recent laboratory measurements of the far infrared absorption of  $H_2$  and mixtures of  $H_2$  with  $CH_4$  and He and the fitting of the pure  $H_2$  spectra with a semi-empirical line shape. Such results are needed in analyzing the thermal emission from the atmospheres of the outer planets. The spectra discussed here, which are forbidden in the isolated molecule, are due to dipoles induced in colliding molecules by their electric fields.

21166. Birnbaum, G.; Berger, H.; Eitzen, D. G. Traceable NDE standards, *NTIAC Newsl.* 9, No. 3, 1-4 (Sept. 1981).

Key words: acoustic emission; eddy currents; leak rate measurements; liquid penetrants; magnetic particles; neutron radiography; traceable NDE; visual acuity.

Recent work at the National Bureau of Standards which has led to NDE standards and calibrations as well as work in progress is reviewed. The NDE areas discussed include acoustic emission, x-ray and neutron radiography, eddy current, magnetic particles, liquid penetrants, visual acuity testing and leak rate measurements.

21167. Birnbaum, G. Determination of molecular constants from collision-induced far-infrared spectra and related methods, *Book: Intermolecular Spectroscopy and Dynamical Properties of Dense Systems LXXXV*, 111-145 (Soc. Italiana di Fisica, Bologna, Italy, 1980).

Key words: collision-induced dipoles; collision-induced spectra; dielectric virial; intermolecular interactions; molecular constants; spectral shape.

This paper describes how quantitative information on molecular parameters, particularly the electric multipole moments, can be obtained from collision-induced absorption spectra. Also discussed are related methods based on the second dielectric virial coefficient and birefringence induced by an externally applied electric field.

21168. Casella, R. C. Relations between Fermion masses from effective potentials in internal space, *Il Nuovo Cimento* 67 A, No. 4, 289-297 (Feb. 21, 1982).

Key words: Fermion masses; internal spaces; mixing angles; neutrino oscillations; potentials; scaling.

The assumption of approximately similar effective potentials in internal space acting on "scale particles" leads to relations among the quark and lepton masses and their weak-interaction mixing angles. The mass of the t-quark is predicted to be 27 GeV. The model also implies that the  $(\nu_\mu, \nu_e)$  and  $(s, d)$  mixing angles are of comparable magnitude, siding against the high-mass solutions for neutrino oscillation accelerator experiments involving  $\nu_\mu \rightarrow \nu_e$ .

21169. de Wit, R.; Smith, J. H. Development of some analytical fracture mechanics models for surface defects in plates of ductile metals, (Proc. Third Int. Symp. Continuum Models of Discrete Systems, Freudenstadt, Germany, June 24-30, 1979), Paper in *Continuum Models of Discrete Systems (CMD53)*, pp. 865-890 (University of Waterloo Press, Waterloo, Ontario, Canada, 1980).

Key words: collapse; cracks; defects; failure; fracture mechanics; girth welds; pipeline; plasticity; strength; stress; toughness.

Fracture mechanics methods have been used to provide a basis for assessing the significance of defects in pipeline girth welds. Analytical models based on fracture mechanics technology are developed to establish predicted critical defect sizes for sharp defects in plates of ductile metal. The general problem considered here is that of a surface defect in a plate under tension. Both infinite and finite width plates are treated. Failure is considered to occur when the ligament ruptures. The fracture mechanics model used, called the collapsed ligament model, is based on the work of Erdogan and Bakioglu which is in turn based on the Dugdale model. The collapsed ligament model assumes plastic collapse in the depth direction, but any fracture mechanics model in the length direction. Curves are derived for the expected predicted critical defect sizes, in which the defect depth is plotted versus the defect length for a given set of material properties and applied stress. Given a particular defect, if the point falls below the curve, the defect is safe, but if the point falls above the curve, failure is predicted.

21170. Hall, J. L.; Baer, T.; Hollberg, L.; Robinson, H. G. Precision spectroscopy and laser frequency control using FM sideband optical heterodyne techniques, (Proc. Fifth Int. Conf. Laser Spectroscopy, Jasper, Alberta, Canada, June 29-July 3, 1981), Paper in *Laser Spectrosc.* V, A. R. W. McKellar, T. Oka, and B. P. Stoicheff, eds., 15-24 (Springer-Verlag, Heidelberg, 1981).

Key words: FM spectroscopy; laser frequency control; optical heterodyne spectroscopy; precision laser spectroscopy.

We discuss the new hybrid rf/optical technique of FM sideband optical heterodyne spectroscopy. We present a simple theory for the expected line shapes and compare with precise experimental data taken in  $I_2$  and in HF. Use of the technique for laser stabilization is also reported.

21171. Langer, S. H.; Rappaport, S. Low-luminosity accretion onto magnetized neutron stars, *Astrophys. J.* 257, No. 2, 733-751 (June 15, 1982).

Key words: radiation mechanisms; stars, accretion; stars, magnetic; stars, neutron; x rays, binaries.

We have studied the behavior of matter accreting at low rates ( $\dot{M} < 10^{16} \text{ g s}^{-1}$ ) onto the polar caps of a highly magnetized ( $B \sim 10^{12}$  gauss) neutron star. We have found flow solutions for the case in which the matter undergoes a stationary, collisionless shock. The electron and ion fluids are treated separately, and the ion temperature is found to be much higher than the electron temperature throughout the flow. At these low accretion rates, the emitted radiation is assumed to exert no significant pressure on the infalling matter and is further assumed to escape from the column without significant degradation in energy. We find that cyclotron emission is the dominant energy loss mechanism and can yield continuum spectra resembling those observed from X-ray pulsars. From the model, we compute a number of relations among the accretion rate, the surface magnetic field, the shock height, and the characteristic electron and ion temperatures. For magnetic fields  $> 10^{12}$  gauss, typical values of  $kT_e$  are several times the cyclotron energy at the surface of the neutron star. When the magnetic field drops below  $\sim 10^{12}$  gauss, the electrons become very hot and emit  $\gamma$ -rays. The self-consistency of our assumptions and results are discussed in detail. Finally, we show how, in the next generation of such calculations, the radiation pressure can be coupled to the hydrodynamic equations.

21172. Netzer, F. P.; Madey, T. E. Structure and orientation of  $NH_3$  on clean and oxygen-precovered Al(111), *Chem. Phys. Lett.* 88, No. 3, 315-320 (May 7, 1982).

Key words: Al(111); ammonia; desorption; electron stimulated desorption ion angular distribution; surface chemistry; surface structure.

On clean Al(111) bonding of molecular  $NH_3$  occurs via the N atom with a wide distribution of tilt angles of the molecular axis with respect to the surface normal and with random azimuthal orientation. Fractional monolayers of chemisorbed oxygen induce a high degree of local azimuthal orientation of the H atoms in adsorbed  $NH_3$ , in the absence of long-range order.

21173. Birnbaum, G.; Guillot, B.; Bratos, S. Theory of collision-



Key words: collision-induced absorption; collision-induced light scattering; far infrared absorption; induced dipole; line shape; rare gas mixtures; spectra; transient dipoles.

The great emphasis given to line shape calculations in collision-induced absorption (CIA) and collision-induced light scattering (CILS) has produced an amazing variety of results exploring, it would seem, almost every nuance of the subject. In one of the first calculations based on eliminating the potential, which produced a shape in very good agreement with experiment, the conclusion was reached that collision-induced line shapes may be rather insensitive to the form of the potential function. This conclusion has been strengthened by many subsequent investigations. But this is not to say, however, that studies of collision-induced shapes cannot yield information regarding the potential function. Since the absolute line shape is much more sensitive to the induction model than the potential function, line shape calculations are very useful for investigating the form of the induction function provided one uses the best potential functions that are available. Since, however, the "best" potential for describing  $n$  phenomena may not necessarily be the best for the  $n+1$ st, we recommend that future attempts to parametrize potential models might be aided by including collision-induced spectral data.

21174. Imam, M. A.; Fraker, A. C.; Speck, K. M.; Gilmore, C. M. Corrosion and corrosion-fatigue behavior of Ti-4.5Al-5Mo-1.5Cr (Corona 5) and Ti-6Al-4V, (Proc. Fourth Int. Conf. Titanium, Kyoto, Japan, May 19-22, 1980), Paper in *Titanium '80*, H. Kimura and O. Izumi, eds., pp. 2595-2604 (Metallurgical Society of AIME, P.O. Box 430, 420 Commonwealth Drive, Warrendale, PA 15086).

Key words: alloys; anodic polarization; corrosion; fatigue; microstructures; titanium.

This paper investigates the alloys, Ti-6Al-4V and Ti-4.5Al-5Mo-1.5Cr in terms of the microstructure and the corrosion-fatigue and general electrochemical behavior in saline solutions. Results show that the anodic polarization behavior in the passive range is quite similar for both alloys and both are highly corrosion resistant to saline solutions. Fatigue data show that at lower strain levels, the Ti-4.5Al-5Mo-1.5Cr alloy has a longer corrosion-fatigue life than the mill annealed Ti-6Al-4V while the opposite is true for higher strains.

21175. Fong, J. T. A deformation analysis of a polyethylene crystal subjected to end forces of stretching and lattice expansion, (Proc. 8th Int. Congr. Rheology, Naples, Italy, Sept. 1980), Paper in *Rheology* **3**, G. Astarita et al., eds., 287-292 (Plenum Press, New York, 1980).

Key words: beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy.

In a recent paper by Hoffman (*Polymer* **20**, 1071-1077 (1979)) on the formation of polymer fibrils by flow-induced crystallization, several assumptions were made in deriving a suitable form of the end surface free energy of a typical crystallite. One of the assumptions was an assertion that the deformation within the crystal as its end surfaces underwent stretching and biaxial expansion, would be approximately uniform. In this paper, a deformation analysis of an idealized square parallelepiped under the combined action of two types of end forces, namely, stretching and lattice-expansion, is performed to assess the validity of the uniform deformation assumption. Taking advantage of the symmetry of the problem and applying the classical solution of a beam on elastic foundation due to Hetenyi (1936, 1946) and Timoshenko (1956), a general result on the ratio of the displacements at the end and the center of the crystal along its line of symmetry can be expressed in terms of the aspect ratio of the crystal, the degree of anisotropy, and the longitudinal strain in the crystal due to stretching. For polyethylene fibril crystal of aspect ratio equal to 6, anisotropy ratio equal to  $3 \times 10^{-3}$ , and a longitudinal strain of 3.6% (maximum to break), the assumption of a uniform deformation throughout the crystal is found to be reasonable as a first approximation.

21176. Fong, J. T. Inservice data reporting and analysis for pressure vessels, piping, pumps and valves, (Proc. Winter Annu. Meet. American Society of Mechanical Engineers, San Francisco, CA,

Dec. 10-15, 1978), *ASME Pressure Vessel & Piping Symp. Ser.*, J. T. Fong, ed., pp. iii-vi (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1978).

Key words: database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve.

The American Society of Mechanical Engineers (ASME), through its Pressure Vessel and Piping Division as the principal sponsor, and three other co-sponsoring divisions (Design Engineering, Materials, and Nuclear Engineering), has scheduled a two-session symposium on the subject of inservice data reporting and analysis during its Winter Annual Meeting (December 10-15) of 1978. The goals of the symposium are: (a) To examine, on a world-wide basis, the current status of reporting, collection, and evaluation of failure data on pressure vessels, piping, pumps, and valves for the purpose of improving the science of estimating the probability of infrequent events such as the failure of mechanical components. (b) To discuss the various approaches currently used world-wide for reliability data collection and reporting on mechanical components in nuclear powerplants to ensure suitability of data to risk analysis.

This special publication contains the original manuscripts of 20 contributors from France, Germany, United Kingdom, and United States in the form of 13 technical papers.

21177. Fong, J. T. Inservice data reporting standards for engineering reliability and risk analysis, *Nucl. Eng. Des.* **60**, 159-161 (1980).

Key words: engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; structural engineering.

On two recent occasions, structural and mechanical engineers were challenged either to come up with a solution to the data base problem of the reliability analysis methodology or to avoid using the tool as a serious mathematical model to resolve issues of safety and productivity. The two occasions were: (1) The September 1978 publication of an assessment of the 1975 Reactor Safety Study (WASH-1400), by a review panel by H.W. Lewis. (2) The convening in December 1978 of an international symposium on inservice data reporting and analysis, sponsored by the American Society of Mechanical Engineers and held at San Francisco.

This paper is a direct response to the challenge. The notion of an adequate data base is first defined in terms of three essential elements. It is then demonstrated via a medical analogy that an 'optimal' plan of data reporting and some national or international standards for such reporting are desirable. A formula for estimating variabilities based on a combination of inservice and failure data is proposed.

21178. Gadzuk, J. W.; Metiu, H. Electron-hole pairs, molecular vibrations, and rate processes at metal surfaces, Paper in *Vibrations at Surfaces*, R. Caudano, J. M. Gilles, and A. A. Lucas, eds., pp. 519-540 (Plenum Publ. Corp., 1982).

Key words: electron-hole pairs; Franck-Condon factors; surface reactions; trajectories; vibrational spectroscopy.

Consequences of the coupling of nuclear motion of an atom or molecule near a metal surface with the electron-hole pair excitations of the metal are considered from the point of view of vibrational spectroscopy. Special emphasis is placed on the interrelationship between pair excitation, surface localized vibrational structure, and rate processes. Specific realizations discussed here in terms of vibrational spectroscopy include: a. Pair renormalization of intramolecular vibrational modes. b. Desorption rates. c. Pair excitation, trajectory theories, and vibrational modes. d. Reaction rate theory at surfaces.

21179. Ryabtsev, A. N.; Reader, J. Spectra of the cobaltlike ions Sr XII, Y XIII, Zr XIV, Nb XV, and Mo XVI, *J. Opt. Soc. Am.* **72**, No. 6, 710-716 (June 1982).

Key words: molybdenum; niobium; spectra; strontium; vacuum ultraviolet; yttrium; zirconium.

Spectra of the cobaltlike ions Sr XII, Y XIII, Zr XIV, Nb XV, and Mo



xvi have been observed by means of a low-inductance vacuum spark and a 10.7-m grazing-incidence spectrograph in the region 40–95 Å. For Y xiii, Zr xiv, Nb xv, and Mo xvi more than 40 transitions of the type  $3d^9-3d^84p$  were identified in each ion. For Sr xii about 20 such transitions were identified. The identifications were made with the aid of Hartree-Fock and least-squares parametric calculations. New wavelengths were obtained for the  $3p^63d^9-3p^53d^{10}$  transitions in these ions. The previous analysis of Mo xvi was partially revised and extended.

**21180.** Takagi, S.; Mathew, M.; Brown, W. E. The structure of sodium strontium phosphate nonahydrate, *Acta Crystallogr.* B38, 1408-1413 (1982).

Key words: crystal structure; hydrated phosphate; strontium phosphate; struvite-type structure.

The crystal structure of  $\text{SrNaPO}_4 \cdot 9\text{H}_2\text{O}$  has been determined by single-crystal X-ray diffraction. The crystals are cubic,  $a = 10.544(2)$  Å, space group  $P2_13$ , with  $Z = 4$ ,  $\rho_m = 2.11$ ,  $\rho_c = 2.083 \text{ g cm}^{-3}$ . The structure was refined by full-matrix least-squares techniques to  $R = 0.025$  and  $R_w = 0.026$  for the 323 reflections used in the refinement. All cations and anions are completely surrounded by water molecules. All nine water molecules are coordinated to the same  $\text{Sr}^{2+}$  ion, forming a tricapped trigonal prism. The  $\text{Na}^+$  ion is coordinated to six water molecules, forming a distorted octahedron. Extensive edge-sharing of  $\text{Sr}(\text{H}_2\text{O})_9$  and  $\text{Na}(\text{H}_2\text{O})_6$  polyhedra exists. The environment of the  $\text{PO}_4^{3-}$  ion consists of 15 water molecules all of which are probably hydrogen bonded to  $\text{PO}_4$  oxygens. However, there is considerable disordering of the phosphate O atoms, somewhat similar to those of  $\text{SO}_4$  groups in alums.

**21181.** Berger, H.; Mordfin, L. What is NBS doing in NDE?, *Proc. 36th Annu. Quality Congr. Transactions, Westin Hotel, Detroit, MI, May 2-5, 1982*, pp. 929-933 (American Society for Quality Control, Inc., 230 West Wells Street, Milwaukee, WI 53203, 1982).

Key words: acoustic emission simulator; acoustic emission transducers; nondestructive evaluation; penetrant test block; traceable measurements; ultrasonic reference blocks; ultrasonic transducers; x-ray magnifier.

The National Bureau of Standards (NBS) has had an active program in nondestructive evaluation (NDE) for several years. The program has been directed toward the development of NDE standards and improved NDE measurement capabilities. Several NDE measurements are now traceable to NBS and others are planned. These procedures provide for more reliable NDE measurements in quality control programs.

**21182.** Hosler, W. R. Electrical conductivity measurements on mixed ionic/electronic conducting materials at high temperatures, (Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Gaithersburg, MD, June 15-18, 1981), Paper in *Thermophysical Properties of Solids and of Selected Fluids for Energy Technology*, II, J. V. Sengers, ed., 138-143 (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017).

Key words: coal slag; conductivity; high temperature; impedance; resistivity.

Measurements of the physical properties of materials at high temperatures are becoming increasingly important, particularly with respect to emerging energy technologies. A technique has been developed for the measurement of the electrical conductivity of some of the materials which are particularly difficult to handle. Contacts are made by using spongy platinum peened around the leads in holes drilled in the sample. For those samples that become liquid at some temperature during the course of the measurement, a leak-tight seal is made in the crucible using spongy platinum compressed around the leadout through the crucible. As examples, measurements on coal slag,  $\text{ZrO}_2 \cdot 12\text{Y}_2\text{O}_3$  and Na-beta alumina are described. Four probe DC and AC (40 Hz to 40 kHz) conductivities are in good agreement. Additional voltage data were obtained on all probe sets. The differences between these AC and DC voltages developed on the various probe sets give an indication of the contribution of ionic conductivity.

**21183.** Carroll, J. J.; Ceyer, S. T.; Melmed, A. J. Optical constants of (001) niobium in the visible region, *J. Opt. Soc. Am.* 72, No. 5, 668-670 (May 1982).

Key words: dielectric constants; ellipsometry; niobium; optical constants; reflectance; refractive index.

Optical constants, measured ellipsometrically at wavelengths between 400.0 and 632.8 nm, are reported for atomically clean (001) niobium. The results are compared with literature values.

**21184.** Galloway, K. F.; Mayo, S. Radiation levels associated with the electron-beam metallization process, *Solid State Technol.*, pp. 96-100 (May 1979).

Key words: device fabrication; electron-beam metallization; electron devices; ionizing radiation; microelectronics; process-related radiation damage; radiation dose.

Ionizing radiation exposure is a natural consequence of the electron-beam metallization process used in device fabrication. Techniques for obtaining the radiation levels associated with electron-beam metallization and the levels for some typical situations are given in this paper. In addition, the consequences of this process-related radiation exposure are briefly discussed.

**21185.** Tech, J. L.; Lovas, F. J.; Fuhr, J. R. Observatory reports: The National Bureau of Standards, *Bull. Am. Astron. Soc.* 14, No. 1, 365-369 (1982).

Key words: atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities.

Spectroscopic research done at NBS of astronomical interest is described.

**21186.** Hogg, D. C.; Guiraud, F. O.; Howard, J.; Newell, A. C.; Kremer, D. P.; Repjar, A. G. An antenna for dual-wavelength radiometry at 21 and 32 GHz, *IEEE Trans. Antennas Propag.* AP-27, No. 6, 764-771 (Nov. 1979).

Key words: corrugated feed; near-field scanning application; offset, antenna; remote sensing of atmosphere.

Accurate multiwavelength remote sensing of the atmosphere requires antennas with the same beamwidth at the various frequencies of operation. A single offset antenna with a corrugated feed which meets this criterion at 20.6 and 31.65 GHz is described. The planar near-field (PNF) scanning facility at the National Bureau of Standards (NBS) was utilized to measure the near-field patterns of the overall antenna for various feed positions, and with an apodizer placed on the reflector. Comparison of the far-field patterns, calculated using PNF methods, yielded the optimum configuration. In addition, the facility was used as a far-field range to measure the radiation pattern of the feed. The antenna is presently installed at Stapleton International Airport, Denver, CO, in a dual-channel radiometric system which continuously remotely senses water vapor and liquid, and it is performing satisfactorily.

**21187.** Weber, L. A. Measurements of the specific heat,  $C_p$ , of ethylene, *J. Chem. Eng. Data* 27, No. 2, 203-207 (Apr. 1982).

Key words: coexistence; ethylene; heat capacity; saturated liquid; specific heat; thermodynamic properties.

We have measured the specific heat,  $C_p$ , of gaseous and liquid ethylene in both the single- and two-phase regions, at pressures to 30 MPa. Temperatures varied from the triple point to 338 K, and densities varied from 0.6 to 2.8 times the critical value. The specific heats of the saturated liquid,  $C_{p,s}$ , are derived. The results are compared with values calculated via the extended Benedict-Webb-Rubin (BWR) equation of state.

**21188.** Allan, D. W. Some methods of maintaining and/or generating time and frequency at arbitrary points on surface of the earth, *J. Inst. Electron. Telecommun. Eng.* 27, No. 10, 383-388 (1981).

Key words: coordinate time; frequency standards; international atomic time; relativity; satellite clocks; SI second;



Moving from terrestrial to satellite techniques for time and frequency comparisons has moved the metrology accuracy from milliseconds and microseconds to microseconds and nanoseconds. GOES and TRANSIT are the only two operational satellite systems from which time and frequency can be obtained, and accuracies of 50  $\mu$ s and 10  $\mu$ s, respectively, are specified. Other experimental satellite techniques will be reviewed—some with accuracies of the order of 1 ns.

Methods of generation of time and of maintaining time at remote locations on the surface of the earth will also be outlined. RMS time deviations of the order of 1 ns in a day and a few microseconds in a year are achievable for state-of-the-art time scale systems.

- 21189.** Berger, H. The 1976 NBS study of girth welds in the Trans-Alaska Oil Pipeline, (Proc. ASNT Fall Conf., Atlanta, GA, Oct. 12-15, 1981), *ASNT Pap. Summ.*, pp. 198-200 (1981).

Key words: defect size measurement; fracture mechanics; girth welds; nondestructive evaluation; pipeline; radiography; regulation.

The purpose of this paper is to introduce a regulatory case study in which technical information played a key role. The problem concerned field-made girth welds in the Trans-Alaska Oil Pipeline. Many of these welds were shown, after they were put in place and covered over, to contain discontinuities larger than those permitted in the federal regulations, 49CFR, Part 195, Department of Transportation (DoT). On August 30, 1976, the Alyeska Pipeline Service Company petitioned DoT to waive the requirements for 612 girth welds, this waiver request based on a fracture mechanics analysis. The National Bureau of Standards (NBS), responding to a request from DoT, formed a 50-person Task Force to address the technical problems related to this matter. The study involved properties of the steel pipe and welds, fracture mechanics analysis and nondestructive measurements to size detected weld discontinuities. NBS-furnished results to DoT played a major role in the regulatory decision to waive requirements for 3 welds, thereby setting a precedent for a waiver based on fracture mechanics analysis.

- 21190.** Boettinger, W. J. The effect of alloy constitution and crystallization kinetics on the formation of metallic glass, *Proc. Fourth Int. Conf. Rapidly Quenched Metals, Sendai, Japan, Aug. 24-28, 1981*, 4 pages (Aug. 1981).

Key words: amorphous alloys; coupled growth; eutectic solidification; metallic glasses; palladium-copper-silicon alloys; rapid solidification.

The relationship between alloy composition, solidification microstructure and ease of metallic glass formation is investigated in Pd-Cu-Si alloys. Experiments are reported on three alloys, Pd<sub>78</sub>Cu<sub>4</sub>Si<sub>18</sub>, Pd<sub>77</sub>Cu<sub>6</sub>Si<sub>17</sub>, and Pd<sub>76</sub>Cu<sub>8</sub>Si<sub>16</sub>, which show the evolution of microstructure and formation of metallic glass as a function of interface velocity.

- 21191.** Wineland, D. J.; Bergquist, J. C.; Drullinger, R. E.; Hemmati, H.; Itano, W. M.; Walls, F. L. Laser cooled, stored ion experiments at NBS and possible applications to microwave and optical frequency standards, *J. Phys. Colloq. C8*, 42, No. 12, C8-307-C8-313 (Dec. 1981).

Key words: atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; ion storage; laser cooling.

Research on stored ion frequency standards at the United States National Bureau of Standards is briefly discussed. We summarize past work and indicate directions of future research.

- 21192.** Walls, F. L.; Howe, D. A. Timekeeping potentials using passive hydrogen masers, *J. Phys. Colloq. C8*, 42, No. 12, C8-151-C8-158 (Dec. 1981).

Key words: frequency drift; frequency stability; hydrogen hyperfine separator; hydrogen maser; timekeeping.

Recent experimental data on the frequency stability of the National Bureau of Standards small passive hydrogen masers indicates that they are superior to any commercially available cesium standard for frequency comparisons or timekeeping out to periods of at least a

month. Frequency drift between the small passive hydrogen maser and an ensemble of nine commercial cesium standards has been measured and is of order  $1 \pm 5 \times 10^{-16}$ /day averaged over 72 days. This is substantially less than the drift in active hydrogen masers. Timekeeping to a few nanoseconds per week has been demonstrated using the small passive hydrogen maser. These small masers are expected to be available in a 30 cm high rack mount in the near future. Using full-sized passive hydrogen masers, it appears possible to achieve frequency stabilities of order  $10^{-15}$  over days and timekeeping to about one nanosecond per week. In order to take full advantage of the improved capabilities of the passive hydrogen masers, it will be necessary to use improved time comparison techniques.

- 21193.** Lin, I. H.; Hirth, J. P. On brittle crack advance by double kink nucleation, *J. Mater. Sci.* 17, 447-460 (1982).

Key words: activation energy for double kink formation; boundary conditions for atomic simulations; brittle crack growth rate; double kink nucleation; edge dislocation pileup; equilibrium jog array; Mode I brittle crack.

A Mode I brittle crack is simulated by a pile-up of edge dislocations. The leading dislocation is a perfect lattice dislocation and the remaining dislocations are sub-dislocations with fractional Burgers vectors. A double kink at the crack-tip is represented by a set of double jogs on the dislocations. The equilibrium jog array is determined for several examples. The calculations give results for the activation energy for double-kink formation and for the elastic field of double kinks. The results are applicable to theoretical estimates of crack-growth rates and in providing boundary conditions for atomic simulations.

- 21194.** McHenry, H. I.; Read, D. T.; Dawes, M. G. Fitness-for-purpose research at the National Bureau of Standards, *Proc. Fitness for Purpose Validation of Welded Constructions, London, England, Nov. 17-19, 1981*, pp. P19-1-P19-10 (The Welding Institute, Abington Hall, Abington, Cambridge CB1 6AL England, 1982).

Key words: crack opening displacement; finite element analysis; fitness-for-service; fracture mechanics; J-integral.

Fitness-for-purpose standards are based on fracture mechanics relationships between applied strain, required toughness, and flaw size. The NBS approach to the establishment of such a relationship for the elastic-plastic case is to measure the driving force for fracture, i.e., the required toughness, as a function of strain in tensile panels for a variety of flaw sizes and configurations. The driving force for fracture is measured in terms of the J-contour integral and the crack opening displacement. The J-contour integral is determined directly by numerical integration of strains and displacements measured on an appropriate contour; the method is used for through cracks and surface cracks. The COD is measured at the crack mouth (CMOD) and estimated for the crack tip (CTOD). The experimental data are compared with finite element analyses and theoretical models. The experimental and analytical results for 2D configurations clearly indicate the importance of crack tip region constraint (CTRC) which significantly reduces the applied J values at strains above yield for crack lengths less than the thickness. Further decreases in J occur for short cracks ( $a/W < 0.02$ ) in a low work-hardening steel because of gross section yielding. Excellent agreement is achieved between experimental and analytical results for surface flaws for both measures of driving force, J and CTOD.

In the use of critical values of J and CTOD as fracture-characterising parameters, consideration must be given to both CTRC and the micromechanisms of crack extension. These factors can be taken into consideration using the concept of a 3D elastic-plastic parameter, which is a function of both CTRC and the micromechanism of crack extension.

- 21195.** Mordfin, L. Toward the nondestructive characterization of fatigue damage in composite materials, (Proc. Damage in Composite Materials, Bal Harbor, FL, Nov. 13-14, 1980), *Am. Soc. Test. Mater., Spec. Tech. Publ.* 775, 7-15 (1982).

Key words: composite materials; damage; fatigue; guys; mechanical testing; nondestructive testing; pultrusions; standards.

This paper is based upon introductory remarks presented at the opening of the ASTM Symposium on Damage in Composite Materials. The cooperation between specialists in fatigue and in



nondestructive testing, in the organization and implementation of the symposium, is marked as a noteworthy milestone in an era in which closer cooperation between these two groups will be needed in order to achieve enhanced quality in materials and manufactured products.

Experiences with an unusual form of damage in pultruded guys for antenna support systems are described to show that the development of meaningful test methods for composites may benefit from unconventional approaches. It is suggested, furthermore, that the development of voluntary standards for the nondestructive characterization of composite materials will succeed only to the extent that individuals with the relevant competences are encouraged to contribute to this important activity.

- 21196.** Kriz, R. D. Absorbed moisture and stress-wave propagation in graphite/epoxy, *Compos. Technol. Rev.* 3, No. 4, 154-155 (1981).

Key words: composites; elastic properties; flux deviation; moisture effects.

By diffusion, the epoxy component of many fiber-reinforced materials can absorb moisture, which is realized as an increase in weight and a decrease in elastic stiffness. This change in elastic stiffness is sufficient to shift the direction of stress-wave propagation in graphite/epoxy.

- 21197.** Kincaid, J. M.; Kayser, R. F., Jr. Kinetic perturbation theory for fluids and fluid mixtures, *Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Gaithersburg, MD, June 15-18, 1981*, I, J. V. Sengers, ed., pp. 189-190 (The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, July 1982).

Key words: Boltzmann equation; collision integral; kinetic theory; perturbation theory; transport coefficient; transport properties.

We prove, for two classes of smooth, repulsive interparticle potentials  $\phi(r) = \phi_0(r) + \lambda\phi_1(r)$ , that the collision integrals of the linearized Boltzmann equation are analytic functions of  $\lambda$  in the neighborhood of  $\lambda=0$ . It then follows, for example, that the first Enskog approximation for the transport coefficients can be represented by a Taylor series in  $\lambda$ . The extension to fluid mixtures is discussed briefly.

- 21198.** Ledbetter, H. M. Stainless-steel elastic constants at low temperatures, *J. Appl. Phys.* 52, No. 3, 1587-1589 (Mar. 1981).

Key words: bulk modulus; elastic constants; low-temperature; magnetic transition; physical properties; Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus.

For stainless steels 304, 310, and 316, longitudinal and transverse ultrasonic velocities were measured by a pulse-echo method between 295 and 4 K. From these velocities were computed five elastic constants: longitudinal modulus, shear modulus, Young's modulus, bulk modulus, and Poisson's ratio. All three steels show low-temperature elastic-constant anomalies, which arise from magnetic phase transitions.

- 21199.** Frank, D. E. Metallic handcuffs, *NIJ Standard-0307.01*, 6 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Mar. 1982).

Key words: ace type pin tumbler lock; cheek plate tamper resistance; salt spray corrosion resistance; warded lock.

This standard establishes minimum performance requirements and test methods for double locking metallic handcuffs intended to be used to restrict the physical movement of apprehended persons. Specific tests are described including visual inspection, dimensional measurements, test loading of handcuffs, test loading of locking mechanism, cheek plate tamper resistance, and salt spray corrosion resistance. This standard is a revision of NILECJ-STD-0307.00, dated October 1974. This standard differs from the base standard in the following areas: 1. The dust test has been deleted. 2. The salt spray test evaluation criteria have been modified. 3. The overall acceptance criteria have been clarified. 4. The dimensions of cheek plate torque bit have been changed.

- 21200.** Baird, R. C. Microwave antenna measurement services at the

National Bureau of Standards, *Proc. Antenna Measurements Symp., Danvers, MA, Oct. 13-15, 1981*, 17 pages (Sanders Associates Inc., Nashua, NH, 1981).

Key words: antenna gain; antenna measurements; antenna pattern; antenna polarization; calibrations; near-field measurements; standard antennas.

This paper reviews and summarizes the microwave antenna measurement services presently available at the National Bureau of Standards, Boulder, Colorado. The extrapolation technique, which is used for accurate calibrations of transfer-standard antennas, is described and its limitations pointed out. With this technique, uncertainties of  $\pm 0.08$  dB to  $\pm 0.10$  dB in absolute gain and  $\pm 0.05$  dB/dB in polarization axial ratio are achieved routinely. Accurate antenna evaluations are also accomplished by means of near-field scanning methods developed at NBS. Most of these measurements have utilized planar near-field scanning, but cylindrical scanning capabilities exist. With this technique, complete patterns are determined in addition to absolute gain to an accuracy of  $\pm 0.15$  dB and polarization axial ratio to  $\pm 0.10$  dB. Side lobes can be obtained down to  $-50$  dB to  $-60$  dB with a typical accuracy of  $\pm 1.0$  dB at the  $-40$  dB level. Examples of measurement results for several different types of antennas are given. Finally, NBS capabilities for measuring the G/T of earth terminals and the thermal noise properties of sources and antennas are mentioned briefly.

- 21201.** Allan, D. W.; Alley, C. O.; Ashby, N.; Decher, R.; Vessot, R. F. C.; Winkler, G. M. R. Ultra-accurate international time and frequency comparison via an orbiting hydrogen-maser clock, *J. Phys. Colloq.* C8, 42, No. 12, C8-395-C8-413 (Dec. 1981).

Key words: Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; satellite; shuttle time; time and frequency metrology; time comparisons.

Hydrogen maser clocks have exhibited fractional frequency stabilities of better than  $1 \times 10^{-15}$  for averaging times as large as 20,000 seconds. This represents an rms time deviation of about 20 ps for 1/4 day prediction times. S-band Doppler cancellation frequency comparison techniques have been developed with phase stabilities of a few picoseconds. Laser ranging systems have been developed with accuracies of a few cm. Combining the virtues of these developments and choosing a satellite with an appropriate orbit would allow worldwide time comparisons at the subnanosecond level, and frequency comparison uncertainties of the order of  $1 \times 10^{-16}$ . Such a capability would open up new horizons to the frequency standards laboratories, to the VLBI community, to the Deep Space Tracking Network, and to fundamental time and frequency (T/F) metrology on a worldwide basis, as well as greatly assisting the BIH in the generation of UTC and TAI.

- 21202.** Wineland, D. J.; Itano, W. M.; Bergquist, J. C.; Walls, F. L. Proposed stored  $^{201}\text{Hg}^+$  ion frequency standards, *Proc. 35th Annu. Frequency Control Symp., Philadelphia, PA, May 27-29, 1981*, pp. 602-610 (Electronic Industries Association, 2001 Eye Street, NW., Washington, DC 20006, 1981).

Key words: atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; microwave frequency standard; optical frequency standard; stored ions.

In this paper, we discuss the performance potential and the problems of implementing a microwave frequency (and time) standard and an optical frequency standard utilizing  $^{201}\text{Hg}^+$  ions stored in a Penning trap. Many of the discussions apply to ion storage-based frequency standards in general. Laser cooling, optical pumping, and optical detection of the microwave or optical clock transition could be achieved using narrowband radiation at the  $194.2 \text{ nm } 6p \ ^2P_{1/2} \leftarrow 6s \ ^2S_{1/2}$  transition, while selectively mixing the ground-state hyperfine levels with appropriate microwave radiation. A first-order field-independent microwave clock transition, which is particularly well-suited to the use of the Penning ion trap is the  $25.9 \text{ GHz } (F, M_F) = (2, 1) \leftrightarrow (1, 1)$  hyperfine transition at a magnetic field of  $0.534 \text{ T}$ . The two-photon Doppler-free  $5d^9 \ 6s^2 \ ^2D_{3/2} \leftrightarrow 5d^{10} \ 6s \ ^2S_{1/2}$  transition at  $563 \text{ nm}$  is a possible candidate for an optical frequency standard. Both standards have the potential of achieving absolute accuracies of better than one part in  $10^{15}$  and frequency stabilities of less than  $10^{-16}$ .



21203. Feldman, M.; Bergquist, J. C.; Lewis, L. L.; Walls, F. L. Preliminary investigation of a new optically pumped atomic rubidium standard, *Proc. 35th Annu. Frequency Control Symp., Philadelphia, PA, May 27-29, 1981*, pp. 625-636 (Electronic Industries Association, 2001 Eye Street, NW., Washington, DC 20006, 1981).

Key words: atomic frequency standard; laser frequency standard; optical pumping; rubidium beam; rubidium cell; rubidium frequency standard.

We are studying two types of optically pumped glass cells which do not contain a buffer gas and have no wall coating in which beam-like properties are exploited. The first device is a sealed glass tube of about 1 cm diameter and 20 cm length. A small amount of  $^{87}\text{Rb}$  metal is localized at one end by temperature gradients which also control the vapor pressure. The cell has the properties of a broad atomic beam for the transport of optically pumped atoms from one end to the other with collimation given by the aspect ratio of the tube. At each end the Rb "beam" is crossed by a laser. In each interaction region, the laser optically pumps atoms into one of the  $5^2\text{S}_{1/2}$  hyperfine levels, as well as detects population changes between the hyperfine levels. In a second device, graphite inserts are included in the glass tube. The graphite strongly getters Rb, thereby providing collimation and significantly reducing scattering of laser light from background Rb atoms. A  $\text{TE}_{011}$  microwave cavity is positioned between the two laser interaction regions.

In the broad beam device we have observed the transport of optically pumped atoms between the ends with a S/N ratio of 300:1 in 1 s. A tunable dye laser was used for the pumping and signal detection. In the collimated beam device, we have observed microwave transitions using a diode laser for pumping and fluorescence detection.

21204. Davis, D. D.; Weiss, M.; Clements, A.; Allan, D. W. Construction and performance characteristics of a prototype NBS/GPS receiver, *Proc. 35th Annu. Frequency Control Symp., Philadelphia, PA, May 27-29, 1981*, pp. 546-552 (Electronic Industries Association, 2001 Eye Street, NW., Washington, DC 20006, 1981).

Key words: automatic time comparison; deep space network; differential time transfer; frequency transfer; Global Positioning System; international time comparison; primary frequency standards; SI second.

The National Bureau of Standards (NBS) has proposed a particular application of the clear access channel C/A of the Global Positioning System (GPS) signal utilizing the fact that the location of two earth stations may be known. Hence, if one has common-view of a single satellite from these two earth stations, excellent time transfer capability exists. NBS has developed a prototype receiver featuring extremely high time transfer accuracy and low cost. Even though one may not know the absolute delays through the receivers, one can do absolute time transfer by knowing the differential delay between two receivers.

The received satellite signals gave an RMS time fluctuation of the receiver output as good as 3.5 nanoseconds for an omni antenna using 15 second averages. The noise was characterized as white noise phase modulation, which can be averaged below the systematics, which are about 1 nanosecond over a thermal range of several degrees about ambient. The day-to-day time fluctuations, when measuring the time difference between the NBS Boulder and U.S. Naval Observatory (USNO) Washington, DC, were about 5 ns.

The software and the receiver are configured to be fully automatic with a Z80A microprocessor setting the amplitude for the lock loops of the receiver and setting the synthesizer which corrects for the nominal Doppler shift. The receiver also has a unique feature of using the microprocessor to calibrate a 0.1 ns built-in time interval counter. All that is required on the part of the user is a local 1 pps tick and a 5 MHz signal, plus his local coordinates.

21205. Itano, W. M.; Lewis, L. L.; Wineland, D. J. Shift of  $^2\text{S}_{1/2}$  hyperfine splittings due to blackbody radiation, *Phys. Rev. A* 25, No. 2, 1233-1235 (Feb. 1982).

Key words: ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure;  $\text{Ba}^+$ ; blackbody radiation; Cs; frequency standards;  $\text{Hg}^+$ .

Frequency shifts of hyperfine splittings of  $^2\text{S}_{1/2}$  states due to the blackbody radiation field are calculated. It is shown that they can be estimated from the dc hyperfine Stark shifts, which have previously been measured in the ground states of hydrogen and the alkali atoms. The shift at 300 K is large enough to be significant in primary Cs atomic beam frequency standards, and should be measurable. A simple method of calculating the hyperfine Stark shifts is described, which is based on the Bates-Damgaard method for determining radial matrix elements and the Fermi-Segrè formula for determining the contact hyperfine matrix elements. It is applied to  $\text{Ba}^+$  and  $\text{Hg}^+$ , for which no experimental data are yet available, and which are currently of interest for frequency standards.

21206. Schaffer, R.; Velapoldi, R. A.; Paule, R. C.; Mandel, J.; Bowers, G. N., Jr.; Copeland, B. E.; Rodgers, D. O.; White, J. C. A multilaboratory-evaluated reference method for the determination of serum sodium, *Clin. Chem.* 27, No. 11, 1824-1828 (1981).

Key words: flame atomic emission spectrometry; interlaboratory performance; reference method; serum sodium analysis statistics.

We carried out a statistically designed, multilaboratory study to evaluate a flame atomic emission spectroscopic (FAES) method for serum sodium as a Reference Method. Definitive values for the serum pools for the study, with sodium in the 110-160 mmol/L range, were determined at the National Bureau of Standards by an ion-exchange/gravimetry method. The multilaboratory FAES results were judged against the preselected performance criteria for the Reference Method: maximum imprecision 1.5 mmol/L, maximum bias 2.0 mmol/L. The standard error of a single laboratory's performance of the method varied with concentration from 0.46 to 0.86 mmol/L with a maximum bias of 1.0 mmol/L; thus, the criteria were satisfied. The cooperating laboratories performed the method with either manual or semi-automated pipetting. Although both modes of pipetting satisfied our acceptability criteria, only the method with semi-automated pipetting is described here as the Reference Method. The statistical results indicate that the precision criterion can be fulfilled with fewer than four replicate analyses.

21207. Masui, R.; Davis, H. A.; Levelt Sengers, J. M. H. A new magnetic suspension densimeter for determining fluid densities by weighing, *Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Gaithersburg, MD, June 15-18, 1981*, I, J. V. Sengers, ed., pp. 128-133 (The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, July 1982).

Key words: capacitance sensing; electronic balance; feedback control; fluid density; hydrostatic weighing; magnetic suspension.

A new magnetic-suspension densimeter has been developed for in-situ measurement of density in pressurized fluids. A small coil, suspended from an electronic balance, surrounds a cylindrical sample cell which contains the sample fluid and a magnetic buoy. As in other magnetic densimeters, the buoy is suspended in the fluid by adjustment of the current through the coil by means of a sensing device and feedback control; here, however, the force on the buoy is not obtained from the value of the support current, but from the increase in weight of the coil as the buoy is brought in support. Sample cell and coil are immersed in a temperature-controlled bath fluid in order to improve thermal contact and to damp the motion of the coil.

The new densimeter requires no accurate sighting or positioning of the buoy, as long as its position is stable, and can therefore be used in opaque fluids and in multiphase systems. Only the volume of the buoy requires calibration; the dependence of the magnetization and/or susceptibility on pressure, temperature, field or time does not have to be known.

21208. Mehl, J. B.; Moldover, M. R. Specific heat and virial coefficient measurements with a spherical acoustic resonator, *Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Gaithersburg, MD, June 15-18, 1981*, I, J. V. Sengers, ed., pp. 134-141 (The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, July 1982).

Key words: equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients.



The ideal gas specific heat  $C_p(T)$  and the acoustic virial  $A_1(T)$  can be determined extremely accurately from speed of sound  $c(P,T)$  data obtained with a spherical resonator. At each temperature,  $T$ , the ratio of the speed of sound of a test gas to the speed of sound of a reference gas can be determined with a precision of a few parts in  $10^6$  by successive measurements of the frequencies and widths of the radial resonances of both gases in the same spherical shell. Molecular relaxation effects are minimized by working at frequencies on the order of 5 kHz. From measurements over a range of temperature and pressure,  $C_p(T)$  can be determined with an accuracy on the order of 0.01%. We have combined two direct measurements of the density virial,  $B(T)$ , of ethylene near 270 K with our own acoustic data to determine  $B(T)$  from 273–373 K. The maximum difference between these acoustic values and independent, highly accurate direct measurements of  $B(T)$  is  $0.8 \text{ cm}^3/\text{mole}$  at 373 K.

**21209.** Howe, D. A.; Allan, D. W.; Barnes, J. A. *Properties of signal sources and measurement methods*, *Proc. 35th Annu. Frequency Control Symp., Philadelphia, PA, May 27-29, 1981*, pp. A 1-A 47 (Electronic Industries Association, 2001 Eye Street, NW., Washington, DC 20006, 1981).

Key words: flicker noise; frequency-domain stability; frequency stability; oscillator noise modeling; power law spectrum; time-domain stability; white noise.

This paper is a review of frequency stability measurement techniques and of noise properties of frequency sources.

First, a historical development of the usefulness of spectrum analysis and time domain measurements will be presented. Then the rationale will be stated for the use of the two-sample (Allan) variance rather than the classical variance. Next, a range of measurement procedures will be outlined with the trade-offs given for the various techniques employed. Methods of interpreting the measurement results will be given. In particular, the five commonly used noise models (white PM, flicker PM, white FM, flicker FM, and random walk FM) and their causes will be discussed. Methods of characterizing systematics will also be given. Confidence intervals on the various measures will be discussed. In addition, we will point out methods of improving this confidence interval for a fixed number of data points.

Topics will be treated in conceptual detail. Only light (fundamental) mathematical treatment will be given.

Although traditional concepts will be detailed, two new topics will be introduced in this paper: (1) accuracy limitations of digital and computer-based analysis and (2) optimizing the results from a fixed set of input data.

The final section will be devoted to fundamental (physical) causes of noise in commonly used frequency standards. Also transforms from time to frequency domain and vice-versa will be given.

**21210.** Lewis, L. L.; Feldman, M. *Optical pumping by lasers in atomic frequency standards*, *Proc. 35th Annu. Frequency Control Symp., Philadelphia, PA, May 27-29, 1981*, pp. 612-624 (Electronic Industries Association, 2001 Eye Street, NW., Washington, DC 20006, 1981).

Key words: atomic frequency standard; laser diode; laser stabilization; light shift; optical pumping.

Single-mode, near-infrared diode lasers may improve the performance of atomic frequency standards. In the case of rubidium standards, the short-term stability may be improved by using laser diodes for optical pumping in place of conventional rf-excited lamps. In cesium beam standards, the lasers may replace both sets of state selection magnets, resulting in greater signal-to-noise, more reliable beam detection, easily reversed beam direction for cavity phase shift measurement, reduced Majorana transitions, and a smaller, more easily regulated C-field. The degree to which these improvements are realized depends upon the characteristics of available lasers. In this paper, we report measurements of laser intensity and frequency noise and their effects on clock performance. The light shift in a laser-pumped Rb clock is given, as well as the stability curve for that clock. Preliminary work on optical pumping in a cesium beam is also reported.

**21211.** Batts, M. E. *Probabilistic description of hurricane wind speeds*, *Am. Soc. Civ. Eng. 108*, ST7, 1643-1647 (July 1982).

Key words: Extreme Type II; hurricanes; Weibull; windspeeds.

This note presents information on the parameters of the best fitting Weibull Distributions estimated for hurricane windspeeds simulated as described in a previous paper, and shows the effect of the incorrect assumption that an Extreme Type I distribution rather than a Weibull distribution, is the appropriate description of the extreme windspeeds.

**21212.** Simiu, E. *Thermal convection and design wind speeds*, *Am. Soc. Civ. Eng. 108*, No. ST7, 1671-1675 (July 1982).

Key words: climatology; extreme winds; fluid mechanics; meteorology; structural engineering; wind.

Estimates are presented of the extent to which the effect of thermal convection upon wind profiles is significant in structural engineering and extreme climatological calculations. The estimates are based upon Monin and Obukhov's theory and recent experimental results reported in the meteorological literature.

**21213.** Gebbie, K. B.; Hill, F.; Toomre, J.; November, L. J.; Simon, G. W.; Gurman, J. B.; Shine, R. A.; Woodgate, B. E.; Athay, R. G.; Bruner, E. C., Jr.; Rehse, R. A.; Tandberg-Hanssen, E. A. *Steady flows in the solar transition region observed with SMM*, *Astrophys. J. 251*, No. 2, L115-L118 (Dec. 15, 1981).

Key words: Solar Maximum Mission; solar transition region; steady velocity fields; Sun.

Steady flows in the quiet solar transition region have been observed with the Ultraviolet Spectrometer and Polarimeter (UVSP) experiment on the *Solar Maximum Mission (SMM)* satellite. The persistent vertical motions seen at disk center have spatial rms amplitudes of  $1.4 \text{ km s}^{-1}$  in the C II line,  $3.9 \text{ km s}^{-1}$  in Si IV, and  $4.2 \text{ km s}^{-1}$  in C IV. The amplitudes of the more horizontal flows seen toward the limb tend to be somewhat higher. Plots of steady vertical velocity versus intensity seen at disk center in Si IV and C IV show two distinct branches.

**21214.** Schermer, R. I.; Boenig, H. J.; Henke, M.; Turner, R. D.; Schramm, R. *Conductor qualification tests for the 30-MJ Bonneville Power Administration SMES coil*, *IEEE Trans. Magn. MAG-17*, No. 1, 356-359 (Jan. 1981).

Key words: cable assembly; fatigue; stability; storage coil; superconductor; useful life.

The 30-MJ energy storage coil for the Bonneville Power Administration requires a low-loss, cryostable conductor that is able to carry 4.9 kA in a field of 2.8 T and will maintain its properties over  $10^8$  partial discharge cycles. The multi-level cable which satisfies these requirements has been extensively tested at various stages in its development and in its final form. Tests have been performed to determine the effect of manufacturing options on ac losses, low temperature electrical resistivity, stability, and fatigue resistance of the insulated conductor. This paper will concentrate on the stability and fatigue tests which have not previously been reported.

**21215.** Repjar, A. G.; Kremer, D. P. *Accurate evaluation of a millimeter wave compact range using planar near-field scanning*, *IEEE Trans. Antennas Propag. AP-30*, No. 3, 419-425 (May 1982).

Key words: antenna measurements; compact range; planar near-field measurements; precision parabolic reflector; radar cross-section measurements.

Significant progress has been made in recent years on planar near-field measurements for antenna calibrations. Such measurements are also useful in the alignment and evaluation of compact ranges because they provide more information than a limited number of analogue plots in one dimension. Contour plots of amplitude and phase data obtained from more complete two-dimensional measurements precisely and accurately locate sources of problems in the range reflector, with phase contour plots being more useful as diagnostic tools.

**21216.** McDowell, R. S.; Patterson, C. W.; Nereson, N. G.; Petersen, F. R.; Wells, J. S. *CO<sub>2</sub> laser coincidences with  $\nu_3$  of SiF<sub>4</sub> near  $9.7 \mu\text{m}$* , *Opt. Lett. 6*, No. 9, 422-424 (Sept. 1981).



Key words: CO<sub>2</sub> saturation spectra; diode laser spectra; heterodyne spectroscopy; isotope enrichment isotope separation; SiF<sub>4</sub> spectra.

Doppler-limited tunable-diode laser spectra of the stretching fundamental ( $\nu_3$ ) of <sup>28</sup>SiF<sub>4</sub> at 1031 cm<sup>-1</sup> have been analyzed and the spectroscopic constants determined. Explicit identifications have been made for transitions near CO<sub>2</sub> laser lines between 1023 and 1038 cm<sup>-1</sup>; 51 such transitions have been observed in sub-Doppler saturation spectra obtained with a CO<sub>2</sub> laser. The closest observed coincidence is  $R(53) F_1^9$  of <sup>28</sup>SiF<sub>4</sub>, at -1.391 MHz from <sup>12</sup>C<sup>16</sup>O<sub>2</sub>  $P(30)$ . Implications for isotope-enrichment experiments are discussed.

21217. Itano, W. M.; Lewis, L. L.; Wineland, D. J. Shift of <sup>2</sup>S<sub>1/2</sub> hyperfine splittings due to blackbody radiation and its influence on frequency standards, *J. Phys. Colloq.* C8 42, No. 12, C8-283-C8-287 (Dec. 1981).

Key words: ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>.

Frequency shifts of hyperfine splittings of <sup>2</sup>S<sub>1/2</sub> states due to the blackbody electric field are calculated. It is shown that they can be estimated from the dc hyperfine Stark shifts, which have previously been measured in the ground states of hydrogen and the alkali atoms. The shifts scale as T<sup>4</sup>. The fractional shift for Cs at 300 K is  $-1.7 \times 10^{-14}$ , which is large enough to be significant in primary frequency standards, and should be measurable. A simple method of calculating the hyperfine Stark shifts is described, which is based on the Bates-Damgaard method for determining radial matrix elements and the Fermi-Segrè formula for determining the contact hyperfine matrix elements. It agrees with the experiment to within 12% for the entire alkali series. It is applied to Ba<sup>+</sup> and Hg<sup>+</sup>, for which no experimental data are yet available, and which are currently of interest for frequency standards. At 300 K, the fractional shifts are  $-9.9 \times 10^{-17}$  and  $-2.4 \times 10^{-15}$  for Hg<sup>+</sup> and Ba<sup>+</sup>, respectively. The shift due to the blackbody magnetic field is  $-1.3 \times 10^{-17} [T(K)/300]^2$  for any <sup>2</sup>S<sub>1/2</sub> state.

21218. Goodrich, L. F.; Fickett, F. R. Critical current measurements: A compendium of experimental results, *Cryogenics* 28, 225-241 (May 1982).

Key words: copper; critical current; electrical property; magnetic field; measurement; niobium; superconductor; tin; titanium.

The results of a programme to evaluate the measurement of the critical current of relatively small (<600 A) practical superconductors are presented. Experimental data showing the effect of various parameters on the measurement are given. Specific areas covered are: experimental design and sample mounting; electric field and resistivity criteria; temporal and spatial variations in the field and current; and temperature and strain effects. The goal of the presentation is to describe the critical current measurement process and its pitfalls in sufficient detail to serve as a guide for those relatively new to the field of practical superconductors.

21219. Lhota, E.; Manninen, M. T.; Pekola, J. P.; Soenne, A. T.; Soulen, R. J., Jr. Comparison of the National Bureau of Standards and the Helsinki temperature scales and its effect on the heat capacity of liquid <sup>3</sup>He below 10 mK, *Phys. Rev. Lett.* 47, No. 8, 590-592 (Aug. 24, 1981).

Key words: beryllium; fixed points; superconductivity; superfluidity; tungsten.

The Helsinki temperature scale, used earlier in measurements of the heat capacity of liquid <sup>3</sup>He (1-10 mK), is compared with the National Bureau of Standards (NBS) noise and nuclear-orientation of the heat capacity of liquid temperature scale. The superfluid transition temperature ( $T_c$ ) of <sup>3</sup>He at zero pressure and the superconductive transition temperatures of tungsten and beryllium were used as fixed points.  $T_c$  on the NBS scale was found to be  $1.025 \pm 0.02$  mK, in close agreement with the Helsinki value 1.04 mK.

21220. Wagner, R. J.; Lavine, C. F.; Cage, M. E.; Dziuba, R. F.; Field, B. F. Measurements of the quantized Hall steps in Si at the ppm level, *Surf. Sci.* 113, 10-15 (1982).

Key words: fine-structure constant; Hall effect; Landau levels; resistance standard; silicon MOSFETs; two-dimensional electron gas.

Hall voltages of n-channel (100)Si MOSFETs have been studied with a high sensitivity potentiometric method. These experiments reveal Hall steps flat to within at least 1 ppm at a temperature of 1.5 K and magnetic field of 13 T. In addition, unanticipated features have been observed near the edges of the Hall steps. Possible explanations for these effects will be discussed.

21221. Le Gouët, J. L.; Picqué, J. L.; Willeumier, F.; Bizau, J. M.; Dhez, P.; Koch, P.; Ederer, D. L. Direct observation of hot-electron spectra from laser-excited sodium vapor, *Phys. Rev. Lett.* 48, No. 9, 600-603 (Mar. 1, 1982).

Key words: associative ionization; energy pooling; lasers; photoelectron spectrum; superelastic collisions.

A sodium atomic beam with density  $10^{13}$  cm<sup>-3</sup> was illuminated by cw dye laser radiation (a few watts per square centimeter) tuned to the D<sub>2</sub> resonance line. In the energy spectrum of the emitted electrons, several lines were observed between 4 and 7 eV. Their positions and intensities indicate that seed electrons are produced either via associative ionization or via collisional ionization from excited states populated by energy-pooling collisions. These electrons are then heated through successive superelastic collisions with excited 3p atoms.

21222. Estlin, A. J.; Stubenrauch, C. F.; Repjar, A. G.; Newell, A. C. Optimized wavelength-sized scalar horns as antenna radiation standards, *IEEE Trans. Instrum. Meas.* IM-31, No. 1, 53-56 (Mar. 1982).

Key words: antenna directivity pattern; antenna measurements; calculated radiation parameters; polarization; standard antennas; VHF-UHF frequency range; wavelength-size scalar horns.

The properties of beamwidth, directivity, and polarization of wavelength-size scalar horns are analyzed and optimized theoretically and confirmed experimentally to determine the usefulness of such horns as standards. Agreement between theoretical predictions and measurements was good.

21223. Datta, S. K.; Shah, A. H.; Fortunko, C. M. Diffraction of medium and long wavelength horizontally polarized shear waves by edge cracks, *J. Appl. Phys.* 53, No. 4, 2895-2902 (Apr. 1982).

Key words: acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves.

Scattering of horizontally polarized shear (SH) waves by edge cracks of length  $l$  and of different orientations relative to the free surface of the half-space is studied. A combined finite element and analytical technique is presented that is suitable for analyzing scattering by cracks or inhomogeneities in a semi-infinite elastic medium. Attention is focused in the range of wavelengths  $\lambda$ , when the ratio  $l/\lambda$  is  $\leq 1/2$ . Numerical results are presented for crack opening displacements and scattered fields on the surface when the medium is homogeneous or when the crack is located in an insert with different material properties. Comparison of the theoretical solution is also made with available experimental results. The experimental results are obtained using electromagnetic-acoustic transducers that can efficiently generate and detect low-frequency SH waves in metals. The results are applicable to sizing and characterization of weld defects. Recent experimental evidence suggests that this can be accomplished when the wavelength is of the order of twice the crack length or longer.

21224. Elsley, R. K.; Fortunko, C. M. Improvements in flaw detection in austenitic stainless steel weldments, *Proc. 1981 Ultrasonics Symp., Chicago, IL, Oct. 14-16, 1981*, pp. 892-899 (Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017, Dec. 1981).

Key words: acoustic waves; elastic anisotropy; nondestructive evaluation; stainless steel; ultrasonic scattering; ultrasonic waves.

Inspection of austenitic stainless steel weldments by conventional



ultrasonic means is fundamentally limited by the textured columnar grain structure of the weld metal. It is shown that for selected angles of incidence, shear waves polarized normal to the columnar grains can pass through the weld metal-base metal interface without partial reflection. As a consequence, the inspectability of stainless steel weldments can be improved. The use of low frequency probing signals is advantageous because it reduces the influence of nonuniform textures at the weld metal-base metal interface. The operation of a low frequency, ultrasonic system for stainless steel butt weldments using electromagnetic acoustic transducers (EMATs) is demonstrated. Digital signal processing techniques including signal averaging, subtraction and synthetic aperture imaging are used to further improve inspectability.

**21225.** Ely, J. F. Prediction of dense fluid viscosities in hydrocarbon mixtures, *Proc. 61st Gas Processors Assoc. Annu. Conv., Dallas, TX, Mar. 15-17, 1982*, pp. 9-17 (Gas Processors Association, Tulsa, OK, 1982).

Key words: corresponding states; Enskog model; equation of state; hard spheres; propane; viscosity.

Recently, Ely and Hanley have proposed a corresponding states model for the prediction of the viscosity and thermal conductivity of hydrocarbon mixtures. The model, which is the basis for the computer program TRAPP which is currently distributed by the Gas Processors Association, uses a methane reference fluid with corrections for noncorrespondence and size difference effects in mixtures. This manuscript reports the preliminary results of some recent modifications which have been made to the corresponding states model in an effort to improve its predictions. In particular, a propane reference fluid has been adopted and a correction for size and mass difference effects in the mixture viscosity coefficient based on the Enskog theory for hard spheres has been developed. Comparisons of the predictions of the revised model with experimental data for both pure fluid and mixture viscosity are presented.

**21226.** Schmidt, W.; Klote, J. In case of fire—Use the stairwells, elevators aren't safe, *Specifying Eng.* 47, No. 5, 82-86 (May 1982).

Key words: building fires; egress; elevators; handicapped; pressurization; smoke control; stairwells.

This paper is the initial report of an ongoing project at NBS to investigate the use of elevators as a means of fire escape for the handicapped. The use of stairwells for fire evacuation poses a problem for people who cannot use stairs because of physical disabilities. This paper discusses some of the major problems associated with the use of elevators as a means of fire exit and proposes a conceptual solution to those problems. A report is made on field test of four buildings with elevator protection systems. These protection systems and their interaction with other systems is examined.

**21227.** Cezairliyan, A.; Müller, A. P. Radiance temperature (at 653 nm) of tungsten at its melting point, *Int. J. Thermophys.* 3, No. 1, 89-99 (1982).

Key words: melting; normal spectral emittance; pulse heating; radiance temperature; tungsten.

The radiance temperature (at 653 nm) of tungsten at its melting point was measured using a subsecond-duration pulse-heating technique. Specimens in the form of strips with initially different surface roughnesses were used. The results do not indicate any dependence of radiance temperature (at the melting point) on initial surface or system operational conditions. The average radiance temperature (at 653 nm) at the melting point for 23 tungsten specimens is 3208 K on IPTS-68, with a standard deviation of 0.8 K and a maximum absolute deviation of 1.9 K. The total error in the radiance temperature is estimated to be not more than  $\pm 10$  K.

**21228.** Levelt Sengers, J. M. H.; Hastings, J. R. Equation of state of ethylene vapor between 223 and 273 K by the Burnett method, *Int. J. Thermophys.* 2, No. 3, 269-288 (Sept. 1981).

Key words: Burnett method; equation of state; ethylene; helium; saturation density; vapor phase; virial coefficients.

Measurements are reported of the equation of state of ethylene in the vapor phase between 223 and 273 K by the Burnett method. ( $P$ ,  $p$ ,  $T$ ) values are reported on six isotherms at 10 K intervals. Virial coefficients have been obtained in this range both for ethylene and for helium. The Burnett isotherms were coupled isochorically; this revealed a small but noticeable adsorption effect. Isochoric intersections with the phase boundary were performed to obtain values for the vapor pressure and the vapor density. Again, clear indications of surface effects were found. Our results have been compared with recent work by Douslin and Harrison, by Waxman and Davis, and by Thomas and Zander. The agreement with the work of Douslin and Harrison is striking: better than 2 parts in  $10^4$  in pressure and better than  $1 \text{ cm}^3 \cdot \text{mol}^{-1}$  in the second virial coefficient. The agreement with the McCarty-Jacobsen formulation is somewhat less satisfactory. A discussion of the various factors determining the reliability of our results is given.

**21229.** Datta, S. K.; Fortunko, C. M.; King, R. B. Sizing of surface cracks in a plate using SH waves, *Proc. 1981 Ultrasonics Symp., Chicago, IL, Oct. 14-16, 1981*, pp. 863-867 (Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017, Dec. 1981).

Key words: acoustic waves; cracks; finite element method; nondestructive evaluation; scattering; ultrasonic waves; variational method.

The diffraction of SH waves by two-dimensional surface cracks in isotropic plates is studied in two different ways. First, a variational integral expression is used to calculate the reflection coefficients of the propagating modes. The scattered fields away from the crack are then obtained using modal superposition. Second, a combined finite element-analytical technique is used to calculate the scattered fields. The results of the two calculations are compared for the case of shallow cracks in the long wavelength limit. The theoretical results are also compared with experimental data that have been obtained using a low frequency (454 kHz) electromagnetic-acoustic transducer (EMAT) system. It is shown that SH waves may be particularly appropriate for detecting and sizing elongated planar defects in butt welds.

**21230.** Mehl, J. B.; Moldover, M. R. Precondensation phenomena in acoustic measurements, *J. Chem. Phys.* 77, No. 1, 455-465 (July 1, 1982).

Key words: acoustical measurements; acoustic resonator; adsorption; nitrogen; physical acoustics; precondensation; propane; sorption; speed of sound; velocity of sound.

Theoretical and experimental studies of the behavior of acoustic resonators whose walls are coated with a film of condensed vapor are reported. As a sound wave is reflected from the resonator walls, further condensation and evaporation will alter the thickness of the condensed film during the course of an acoustic cycle. We have modeled this effect for smooth walls and have calculated the associated specific acoustic admittance, which we refer to as  $\beta_{\text{film}}$ . Over a wide range of conditions, the magnitude of  $\beta_{\text{film}}$  is governed by the derivative of the film thickness with respect to pressure. Thus, for typical adsorption isotherms, the magnitude of  $\beta_{\text{film}}$  becomes large at very low pressures and at pressures just below the saturated vapor pressure. It seems possible that acoustic techniques could be used to study adsorption in both pressure regimes. If the resonator walls are rough (e.g., machined metal), a significant quantity of vapor will condense in the recesses of the walls at pressures well below the saturated vapor pressure. The specific acoustic admittance associated with such thick films is often more than ten times larger than the specific acoustic admittance predicted by the usual Kirchhoff-Helmholtz formula. If this excess wall admittance is not recognized, the resonance frequencies will appear to imply an anomalous decrease in the speed of sound ( $c$ ) as the saturated vapor pressure is approached. Such a decrease in the apparent value of  $c$  of nitrogen has been reported by Younglove and McCarthy, who observed decreases as large as 1%. We demonstrate that the same inhomogeneous precondensation phenomena can easily be seen in propane at ambient temperature. These precondensation phenomena will influence measurements of acoustic virials at low temperatures, as well as the behavior of certain acoustic thermometers. Measurements of acoustic dissipative processes are also strongly affected. We have observed an increase of reflection losses by more than a factor of 200



as the pressure of propane on an aluminum surface was increased from 90% to 99.5% of the saturated vapor pressure.

- 21231.** Mulholland, G.; Ohlemiller, T. J. **Aerosol characterization of a smoldering source**, *Aerosol Sci. Technol.* **1**, 59-71 (1982).

**Key words:** aerosol coagulation; combustion aerosols; particle size distribution; smoke; smoke detection; smoke production; smoldering.

The aerosol emitted by a moderately large smoldering combustion source (16 cm in diameter) has been characterized in detail. The fuel is a permeable bed of cellulosic insulation (wood fibers) receiving its primary air supply by flow up from the bottom of the bed while the smolder wave propagates downward. The mass mean particle size of the aerosol is 2-3  $\mu\text{m}$ ; this shows no clear trend with smolder wave depth in the bed or with air flow velocity. The large average particle size is shown to imply that, compared to punk smoke, the present aerosol requires a sevenfold greater concentration to trigger an ionization detector. Coagulation of the aerosol in the plume above the source is shown to be minimal, but substantial coagulation can occur within the source. The apparent fractional conversion of gasified mass (60-75% of the fuel) to aerosol mass decreases with smolder wave depth in the bed and with decreasing air flow rate. The mass and number flow rate of the aerosol show these same trends. The decreasing aerosol emissions with wave depth or air flow rate are plausibly explained by filtration effects in the smolder bed.

- 21232.** Ruff, A. W.; Lashmore, D. S. **Dry sliding wear studies of nickel-phosphorus and chromium coatings on 0-2 tool steel**, *Am. Soc. Test. Mater., Spec. Tech. Publ.* **769**, 134-156 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, 1982).

**Key words:** chromium; coatings; electrodeposition; metallic glasses; nickel-phosphorus; steel; wear; wear testing.

An investigation of dry sliding wear of electrodeposited nickel-phosphorus and chromium coatings on 0-2 tool steel against 52100 steel has been carried out. Wear and friction measurements were made in an argon atmosphere under dry sliding conditions at 0.2 m/s sliding speed and a load of 10 N. Among the materials studied, significant differences in wear rates were found that depended upon the nature of the coating. This work has determined the wear rates and has examined factors involved in the wear process for nickel-alloy coatings produced using electroless, direct-current, and pulsed-current plating, and chromium coatings. Thermal treatments after plating affected wear performance and indentation hardness. In all the nickel-alloy coatings, a laminar morphology was found that varied with the deposition method and was affected by thermal treatment. The wear test system used in this research was designed to examine flat specimens using a rotating 52100 steel ring as the counterface. The system was computer-interfaced and controlled, which permitted real-time measurements of wear and friction coefficient. These features made the system particularly suitable for studying the wear of thin metal coatings.

- 21233.** Sarbar, M.; Covington, A. K.; Nuttall, R. L.; Goldberg, R. N. **Activity and osmotic coefficients of aqueous potassium carbonate**, *J. Chem. Thermodyn.* **14**, 695-702 (1982).

**Key words:** activity coefficient; electrolytes; excess Gibbs energy; isopiestic; osmotic coefficient; potassium carbonate; solubility; solutions; thermodynamics.

The isopiestic method has been used to determine the osmotic coefficients of aqueous potassium carbonate at molalities ranging from 0.13 to 8.1  $\text{mol}\cdot\text{kg}^{-1}$  at 298.15 K. The solubility has been measured both by the isopiestic method and by titration of the saturated solution with hydrochloric acid and is  $(8.102 \pm 0.008) \text{ mol}\cdot\text{kg}^{-1}$ . The measured osmotic coefficients were used to calculate activity coefficients using four different correlating equations. We give an error estimate and a comparison with previous literature results.

- 21234.** Sarbar, M.; Covington, A. K.; Nuttall, R. L.; Goldberg, R. N. **Activity and osmotic coefficients of aqueous nickel (II) nitrate solutions**, *J. Chem. Thermodyn.* **14**, 537-545 (1982).

**Key words:** activity coefficient; electrolyte; excess Gibbs energy;

isopiestic; nickel nitrate; osmotic coefficient; solubility; solutions; thermodynamics.

The osmotic coefficients of aqueous nickel (II) nitrate have been measured at 298.15 K by the isopiestic method at molalities ranging from 0.052 to 5.5  $\text{mol}\cdot\text{kg}^{-1}$ . The solubility has also been determined by direct analysis of the saturated solution and is  $(5.386 \pm 0.010) \text{ mol}\cdot\text{kg}^{-1}$ . The measured osmotic coefficients were used to calculate activity coefficients using four different correlating equations. Error estimates and comparisons with previous literature values are given.

- 21235.** Fortunko, C. M.; Schramm, R. E. **Ultrasonic nondestructive evaluations of butt welds using electromagnetic-acoustic transducers**, *Weld. J.*, pp. 39-46 (Feb. 1982).

**Key words:** mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; welding evaluation.

A new ultrasonic inspection technique is described for detecting elongated defects in butt welds. The technique uses noncoupling, electromagnetic-acoustic transducers (EMAT's) that can operate on most unprepared surfaces and under adverse environmental conditions. The operation of the new technique is demonstrated in the context of detection and sizing of elongated, two-dimensional defects in girth welds of 1.22-m (48-in) diameter cross-country pipeline. The ultrasonic inspection is carried out at 454 kHz using shear-wave signals polarized in the plane of the weld (SH-waves). The advantage of ultrasonic weld inspection at low frequencies (long wavelengths) is that the reflected ultrasonic amplitude is relatively insensitive to defect orientation and surface roughness.

- 21236.** Fortunko, C. M.; King, R. B.; Tan, M. **Nondestructive evaluation of planar defects in plates using low-frequency shear horizontal waves**, *J. Appl. Phys.* **53**, No. 5, 3450-3458 (May 1982).

**Key words:** acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves.

An ultrasonic technique is described that allows the determination of the through-thickness dimension and limited localization of planar defects (cracks) in an isotropic metal plate. The scattering of horizontally polarized shear (SH) plate waves by edge and buried planar defects is investigated using a variational integral expression. Numerical results are presented that allow the calculation of the SH plate wave signal amplitudes as a function of defect through-thickness dimension and location within a plate for two-dimensional cracks. It is shown that SH waves are particularly useful for detecting and sizing of crack-like defects. In addition, it is demonstrated that in plates, which can support a number of propagating SH plate waves, it is also possible to determine the relative position of a defect from interference phenomena. The numerical results are confirmed experimentally using an electromagnetic-acoustic transducer system to generate and detect 454-kHz SH wave signals along the normal to the circumference of a 1.22-m-diam steel pipe with a 15.9-mm wall thickness. The experimental results demonstrate the efficacy of using SH wave signals in quantitative nondestructive evaluation of butt welds.

- 21237.** Hess, S.; Hanley, H. J. M. **Distortion of the structure of a simple fluid**, *Phys. Rev. A* **25**, No. 3, 1801-1804 (Mar. 1982).

**Key words:** computer simulation; fluid structure; nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; radial distribution function; shear; soft sphere fluid; viscosity.

The distortion of the structure of a simple fluid of spherical particles when subjected to a shear is analyzed. The orientational distribution of particles around a central particle is examined via the radial distribution function. General symmetry arguments are advanced. Computer-simulation results using the technique of homogeneous shear nonequilibrium molecular dynamics are reported for the inverse-12 soft-sphere system. It is shown that the fluid displays non-Newtonian behavior.

- 21238.** Evans, D. J.; Hanley, H. J. M. **Fluctuation expressions for fast thermal transport processes: Vortex viscosity**, *Phys. Rev. A* **25**, No. 3, 1771-1774 (Mar. 1982).



**Key words:** fast transport coefficients; Kubo-Green relation; nonequilibrium dynamics; vortex viscosity.

The vortex viscosity of a model diatomic fluid is calculated using both equilibrium and nonequilibrium molecular dynamics. The two calculations agree within statistical uncertainties. The results show that vortex viscosity does not have a conventional Kubo-Green relation. An argument as to why this is so is presented.

- 21239.** King, R. B.; Fortunko, C. M. Extended variational solution for scattering from flaws in plates, *J. Appl. Phys.* **53**, No. 5, 3459-3460 (May 1982).

**Key words:** elastic waves; flaws; nondestructive evaluation; nondestructive testing; scattering; variational method.

A variational solution is obtained for scattering of horizontally polarized shear (SH) waves from cracks in plates. The solution permits a trial function for the displacement jump across the crack in the form of a series with arbitrary coefficients to be inserted in the variational expression for the scattering coefficients. This multiple term variational solution is preferable to one-term solutions when increased accuracy is desired or when the form of the displacement jump across the crack is not apparent. Numerical results are presented for scattering from edge cracks in plates.

- 21240.** Epstein, G. L.; Reader, J. Spectrum and energy levels of triply ionized yttrium (Y IV), *J. Opt. Soc. Am.* **72**, No. 4, 476-492 (Apr. 1982).

**Key words:** energy level; ionization energy; spark; spectrum; ultraviolet; yttrium.

The spectrum of Y IV was observed in the region from 300 to 5000 Å with the 10.7-m normal-incidence vacuum spectrograph and the 10.7-m Eagle spectrograph in air at the National Bureau of Standards. The light source was a sliding spark discharge. About 560 lines were classified as transitions between 129 energy levels. The observed level system (Kr I isoelectronic sequence) includes nearly all levels of the  $4s^2 4p^6$ ,  $4s^2 4p^5 5s$ ,  $6s$ ,  $7s$ ,  $4d$ ,  $5d$ ,  $6d$ ,  $4f$ ,  $5f$ ,  $5g$ ,  $6g$ , and  $4s 4p^5 4d$  configurations. About 190 lines remain unclassified. All observed configurations have been theoretically interpreted. The energy parameters determined by least-squares fits to the observed levels are compared with Hartree-Fock calculations. The ionization energy as derived from the  $4p^5 ng(n=5, 6)$  levels is  $488\,830 \pm 20 \text{ cm}^{-1}$  ( $60.608 \pm 0.002 \text{ eV}$ ).

- 21241.** Flynn, T. M.; Way, J. D. Membrane separations, *Energy Progr.* **2**, No. 2, 79-82 (June 1982).

**Key words:** chemical engineering; facilitated transport; liquid membrane; membrane; purification; separation.

Rising energy and operating costs have underscored the need for novel energy-efficient separation processes, such as membrane processes, which avoid the energy consuming phase-change step of many conventional separations (e.g., distillation, absorption, stripping). It is well known that membrane separation is the most energy-efficient separation technique thermodynamically possible, since it does not rely upon vaporization and condensation to effect fractionation. Hence, because of recent technological developments of these new membranes, and because of its great energy-savings potential, research is being conducted on the fundamentals determining separation rates, separation factors, and selectivity of new types of solid and liquid membranes with potential application to the chemical process industry.

- 21242.** Fortunko, C. M.; Schramm, R. E. Nondestructive evaluation of large diameter girth welds using electromagnetic-acoustic transducers, *Proc. Fitness for Purpose Validation of Welded Constructions, London, England, Nov. 17-19, 1981*, pp. P20-1-P20-8 (The Welding Institute, Abington Hall, Abington, Cambridge CB1 6AL, England, 1982).

**Key words:** mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; weld evaluation.

A new ultrasonic inspection technique is described to detect elongated defects in butt welds. The technique uses noncoupling, electromagnetic-acoustic transducers (EMATs) which can operate on most unprepared surfaces and under adverse environmental conditions. The operation of the new technique is demonstrated in the context of the detection and sizing of elongated, two-dimensional defects in girth welds of 48 in diameter cross-country pipeline. The ultrasonic inspection is carried out at 454 kHz using shear wave signals polarised in the plane of the weld (SH waves). The advantage of ultrasonic weld inspections at low frequencies (long wavelengths) is that the reflected ultrasonic amplitude is relatively insensitive to defect orientation and surface roughness. Since SH waves can propagate at near-grazing angles, the sensitivity to through-wall, two-dimensional defects can be maximized. These features of the SH wave/EMAT system are particularly attractive when fitness-for-service criteria are used to evaluate welded butt joints.

- 21243.** Ausloos, P.; Lias, S. G.; Rebbert, R. E. Photolysis and radiolysis of cyclopentane in the liquid phase, *J. Phys. Chem.* **85**, No. 16, 2322-2328 (Aug. 6, 1981).

**Key words:** charge recombination; cyclopentane; photofragmentation; photoionization; quantum yields; radiation chemistry; vacuum ultraviolet.

The liquid-phase photolysis of cyclopentane has been investigated at energies below (7.6, 8.4 eV) and above (10.0, 11.6 eV) the ionization threshold (8.7 eV). The molecules excited by photon absorption and by charge recombination undergo four major dissociation processes:  $c\text{-C}_5\text{H}_{10} \rightarrow \text{H} + c\text{-C}_5\text{H}_9$  (I);  $c\text{-C}_5\text{H}_{10} \rightarrow \text{H}_2 + c\text{-C}_5\text{H}_8$  (II);  $c\text{-C}_5\text{H}_{10} \rightarrow 1\text{-C}_5\text{H}_{10}$  (III); and  $c\text{-C}_5\text{H}_{10} \rightarrow \text{C}_2\text{H}_4 + \text{C}_3\text{H}_6$  (IV). The quantum yields of processes I and IV increase drastically with increasing energy at the expense of process II. The ionization quantum yield was estimated to be  $0.26 \pm 0.05$  and  $0.4 \pm 0.1$  at 10.0 and 11.6 eV, respectively, based on chemical scavenging of the parent cyclopentane ions. Electron-scavenging experiments show that, in the radiolysis, neutralization (mainly geminate) of the parent ion leads to the formation of electronically excited molecules which dissociate according to processes I-IV. By comparing the relative abundances of these fragmentation channels with their quantum yields in the photolysis experiments at different energies, it is found that the average excitation energy of the cyclopentane molecules formed by charge recombination is in excess of 10 eV. Partial retention of the internal energy of the parent ions at the time of return of the geminate electron is suggested.

- 21244.** Lashof, T. W. The NBS-TAPPI Collaborative Reference Program—Beginning its second decade, *TAPPI* **63**, No. 4, 61-63 (Apr. 1980).

**Key words:** Collaborative Reference Program; paper; TAPPI; tenth anniversary; testing.

History of NBS-TAPPI Collaborative Reference Program and questions concerning its future direction.

- 21245.** Lang, S. B.; DeReggi, A. S.; Broadhurst, M. G.; Davis, G. T. Effects of poling field and time on pyroelectric coefficient and polarization uniformity in polyvinyl fluoride, *Ferroelectrics* **33**, 119-125 (1981).

**Key words:** ferroelectric; piezoelectric; polarization distribution; poling study; polyvinyl fluoride; pyroelectric.

Electroded films of polyvinyl fluoride (PVF) were polarized with DC electric fields as high as  $315 \text{ MV m}^{-1}$  for periods between 60 and 7200 seconds at room temperature. Thermal pulse data to determine the depth of polarization and pyroelectric coefficients were obtained on all samples. Large pyroelectric coefficients could be produced above a threshold mean polarizing field of  $100 \text{ MV m}^{-1}$ ; with mean fields greater than  $200 \text{ MV m}^{-1}$ , all samples appeared to be uniformly poled with pyroelectric coefficients in the  $12\text{--}16 \mu\text{C m}^{-2} \text{ K}^{-1}$  range. The thermal pulse data definitely established that, in partially-poled samples, the polarization was strongest near the poling cathode. Mathematical techniques were developed for the computation of fraction poled from the thermal pulse data using a nonlinear least squares analysis.

- 21246.** Lucas, L. L.; Noyce, J. R.; Coursey, B. M. The half life of



Key words: alpha-particle-emission rates; liquid-scintillation counting; plutonium-239 (half life); plutonium isotopic abundances; radioactive decay.

The alpha-particle-emission rates of solutions of plutonium-239 metal were determined from defined-solid-angle-counter and liquid-scintillation-counter measurements. These results were combined with composition data obtained from other laboratories and the half life of  $^{239}\text{Pu}$  was calculated to be 24,112 yr. Associated with this value is a standard deviation of the mean of  $\pm 16$  yr and a systematic error of  $\pm 50$  yr.

- 21247.** Van Brunt, R. J.; Leep, D. A. **Corona-induced decomposition of  $\text{SF}_6$** , (Proc. Third Int. Symp. Gaseous Dielectrics, Knoxville, TN, Mar. 7-11, 1982), Paper in *Gaseous Dielectrics III*, 402-409 (Pergamon Press, New York, NY, 1982).

Key words: corona discharge; corona pulse characteristics; decomposition products; gas chromatograph-mass spectrometer;  $\text{H}_2\text{O}$ ; sulfur hexafluoride.

The stable, neutral decomposition products resulting from positive point-plane dc corona in static  $\text{SF}_6$  gas have been identified with a gas chromatograph-mass spectrometer. Absolute concentrations of some species have been measured with a sensitivity of  $\sim 1$  ppm as a function of total energy dissipated for discharge power levels between 50 and 700 mW. The first detectable gaseous contaminant to appear is  $\text{H}_2\text{O}$ , presumably liberated by discharge-induced desorption from the electrode. The oxyfluorides  $\text{SOF}_2$ ,  $\text{SO}_2\text{F}_2$ , and  $\text{SOF}_4$  are the next most prominent species to appear. Other species such as  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{CF}_4$ ,  $\text{OCS}$ , and  $\text{SO}_2$  were identified. For corona levels below 700 mW,  $\text{SOF}_2$  and  $\text{SO}_2\text{F}_2$  appear with nearly equal concentrations, and the production rates for both are constant and proportional to discharge power. The presence of trace amounts of  $\text{H}_2\text{O}$  and other decomposition products is found to have a pronounced effect in suppressing the pulse burst characteristic of positive corona in  $\text{SF}_6$ .

- 21248.** Lyon, G. **Some hashing requirements in perspective (Extended Abstract)**, *Proc. 1980 Conf. Information Sciences and Systems*, Princeton, NJ, Mar. 26-28, 1980, p. 443 (Princeton University, Princeton, NJ, 1980).

Key words: assignment; Brent's algorithm; double hashing; requirements; retrieval; Sharp's algorithm.

Refinements and variations on hashing techniques may achieve their performance by shifting the field of application. Two points based upon Brent's method advance the argument that such refinements are not always unqualified improvements.

- 21249.** Lindstrom, R. M.; Fleming, R. F. **Accuracy in activation analysis: Count rate effects**, (Proc. 4th Int. Conf. Nuclear Methods in Environmental and Energy Research, Columbia, MO, Apr. 14-17, 1980), *DOE CONF-800433*, pp. 25-35 (1980).

Key words: accuracy; activation analysis; count rate effects; dead time; errors; pulse pileup.

The accuracy inherent in activation analysis is ultimately limited by the uncertainty of counting statistics. When careful attention is paid to detail, several workers have shown that all systematic errors can be reduced to an insignificant fraction of the total uncertainty, even when the statistical limit is well below one percent.

A matter of particular importance is the reduction of errors due to high counting rate. The loss of counts due to random coincidence (pulse pileup) in the amplifier and to digitization time in the ADC may be treated as a series combination of extending and non-extending dead times, respectively. The two effects are experimentally distinct. Live timer circuits in commercial multi-channel analyzers compensate properly for ADC dead time for long-lived sources, but not for pileup. Several satisfactory solutions are available, including pileup rejection and dead time correction circuits, loss-free ADCs, and computed corrections in a calibrated system. These methods are sufficiently reliable and well understood that a decaying source can be measured routinely with acceptably small errors at a dead time as high as 20 percent.

- 21250.** Knoll, M. B. **Information retrieval theory and design based on a model of the user's concept relations**, *Proc. Symp. Research and Development in Information Retrieval*, Cambridge, England, June 23-27, 1980, pp. 77-93 (Butterworths, London, England, 1981).

Key words: automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations.

Viewing IR systems as models of human assessment of the similarity between requests and documents contributes to development of theory for IR and can aid in development of IR systems. This paper reports on the development and testing of a theory of IR based on this system-as-model view. The principal claim of the theory is that the ability of an IR system to retrieve relevant documents is dependent on the agreement between the system's and users' models of concept relations. The theory provides an explanation for the value of co-occurrence data. Results of an experiment provide support for the theory, and for using co-occurrence data in retrieval systems. Implications for IR research and development are considered.

- 21251.** Lewis, L. L.; Walls, F. L.; Glaze, D. J. **Design considerations and performance of NBS-6, the NBS primary frequency standard**, (Proc. 3d Int. Symp. Frequency Standards and Metrology, Aussois, France, Oct. 12-14, 1981), *J. Phys. Colloq.* **C8**, 42, No. 12, C8-241-C8-246 (Dec. 1981).

Key words: cavity phase shift; cesium clock; frequency standard evaluation; frequency standard uncertainties; NBS-6; primary standard.

The construction and performance of NBS-6, the U.S. cesium primary frequency standard, are summarized. A brief description of evaluation procedures and sources of uncertainty are given.

- 21252.** Lewis, L. L.; Feldman, M.; Bergquist, J. C. **Impact of lasers on primary frequency standards and precision spectroscopy**, (Proc. 3d Int. Symp. Frequency Standards and Metrology, Aussois, France, Oct. 12-14, 1981), *J. Phys. Colloq.* **C8**, 42, No. 12, C8-271-C8-281 (Dec. 1981).

Key words: atomic beams; cesium; frequency standards; lasers; metrology; spectroscopy.

Lasers available at new wavelengths, powers, linewidths, and stabilities have made possible advances in precision atomic frequency standards and spectroscopy. Laser spectrometers with resolving power exceeding  $10^{11}$  have been constructed and used to measure the photon recoil structure of spectral lines and in new tests of relativity. Recent progress in frequency stabilization methods and in laser-cooled ions indicates the possibility of an optical frequency standard with an accuracy and stability of less than  $10^{-15}$ . Diode lasers may enable the construction of an optically-pumped cesium standard with an order-of-magnitude improvement in accuracy over existing primary standards.

- 21253.** Fortunko, C. M.; Moulder, J. C. **Ultrasonic inspection of stainless steel butt welds using horizontally polarized shear waves**, *Ultrasonics*, pp. 113-117 (May 1982).

Key words: elastic anisotropy; flaw detection; horizontally polarized shear waves; stainless steel; ultrasonic testing.

Inspection of austenitic stainless steel weldments by conventional ultrasonic means is fundamentally limited by the textured, columnar grain structure of the weld metal. It is shown that, for selected angles of incidence, shear waves normally polarized with respect to the columnar grains can pass through the weld metal-base metal interface without partial reflection. As a consequence, the inspectability of stainless steel weldments can be improved. The operation of a low frequency, ultrasonic system for stainless steel butt weldments is demonstrated.

- 21254.** Herron, J. T.; Martinez, R. I.; Huie, R. E. **Kinetics and energetics of the Criegee intermediate in the gas phase. I. The Criegee intermediate in ozone-alkene reactions**, *Int. J. Chem. Kinet.* **14**, 201-224 (1982).



Key words: alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry.

The chemistry and energetics of the Criegee intermediate, a primary product of the ozonolysis of alkenes, are discussed in terms of recent *ab initio* calculations and laboratory studies.

21255. Herron, J. T.; Martinez, R. I.; Huie, R. E. Kinetics and energetics of the Criegee intermediate in the gas phase. II. The Criegee intermediate in the photooxidation of formaldehyde, in alkylidioxo disproportionation and O+oxoalkane addition reactions, *Int. J. Chem. Kinet.* **14**, 225-236 (1982).

Key words: alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry.

The gas-phase kinetics and energetics of the Criegee intermediate, deduced from studies of O<sub>3</sub>-alkene systems, suggest that a hydroxy-substituted Criegee intermediate probably participates in the photooxidation of formaldehyde. In contradistinction, the existing evidence suggests that the Criegee intermediate and its isomers are probably not involved in alkylidioxo disproportionation reactions. In the case of O+oxoalkane addition reactions, the Criegee intermediate and its isomers are discussed in terms of a complex equilibrium: O+oxoalkane $\rightleftharpoons$ [O+oxoalkane adduct].

21256. Jason, N. Research and development: Federal programs develop new arson technologies, *Firehouse*, pp. 54-55 (Aug. 1981).

Key words: accelerants; arson; decision analysis; fire investigations; firesetters.

As part of the federal fight against arson, the Center for Fire Research (CFR) at the National Bureau of Standards (NBS) in Washington, D.C. has a statutory mandate to carry out programs related to scientific aspects of the arson problem. In cooperation with other federal agencies, CFR researchers have undertaken several projects. They are the Fire Investigation Handbook, arson sniffers, the psychology of arson, arson laboratory accelerant analysis and decision analysis.

21257. Kuriyama, M.; Boettinger, W. J.; Cohen, G. G. Synchrotron radiation topography, *Annu. Rev. Mater. Sci.* **12**, 23-50 (1982).

Key words: image formation; kinetic study; materials science; synchrotron radiation; topography; x ray.

Synchrotron x-ray topography has its roots in classical laboratory x-ray work performed between 1930 and 1960. The ability of the x-ray topographic technique to image microstructural details related to crystalline imperfection, has long given it a position of importance in materials science.

21258. Kuriyama, M.; Cohen, G. G. X-ray extinction theory in the Bragg geometry, *Z. Naturforsch.* **37a**, 465-473 (1982).

Key words: dynamical diffraction theory; x-ray extinction; x-ray imaging; x-ray topography.

In view of the renewed interest in surface reflection x-ray topography, a unified theory for the Bragg geometry has been laid out to explain the different types of image formation from the scattering point of view. The means by which the photons "infiltrate" a real crystal have been studied. The theory suggests, for example, a mechanism for image contrast inversion in the Bragg geometry, and will also be found to be important in other topics of high current interest, such as x-ray standing wave surface analysis and x-ray inelastic scattering at the Bragg angle.

21259. Boettinger, W. J.; Dobbins, R. C.; Burdette, H. E.; Kuriyama, M. Real time topography with x-ray image magnification, *Nucl. Instrum. Methods* **195**, 355-361 (1982).

Key words: multicrystal diffraction; real time; synchrotron; topography; x-ray image magnification.

An X-ray optical configuration for real time synchrotron radiation topography is described. Asymmetric diffraction from perfect Si crystals is used to control the beam size, wavelength, and collimation before the sample, and to magnify the X-ray image after the sample. Preliminary results using this system are reported. Video images of moving magnetic domain walls under a varying magnetic field were obtained from Ni single crystals in the anomalous transmission geometry.

21260. Schneider, S. J.; Negas, T.; Frederikse, H. P. R. An assessment of materials requirements and research needs for open cycle magnetohydrodynamics (MHD) systems, *Pure Appl. Chem.* **54**, No. 7, 1325-1334 (1982).

Key words: fuel cells; gas turbines; high temperature needs; materials problems; MHD.

Major programs are underway in the United States and elsewhere to develop and demonstrate a number of advanced coal-to-electricity conversion systems. The principal efforts are centered on MHD, fuel cells, and gas turbines as these technologies hold more or less equal promise to fulfill the potpourri of needs of the utilities and industry. All, however, have equally challenging technical problems which ultimately relate to the degradation of materials under extremely hostile service conditions.

For MHD, significant progress in engineering component development has been made and no longer are "proof of concept" and commercial feasibility questioned. Acceptance of the technology by the industrial sector still requires further demonstration of the performance, reliability, and durability of many interacting parts and components. Durability and reliability of MHD materials of construction are indeed prime issues which probably can be resolved through a combination of engineering/economic trade-offs and materials development derived from directed basic and applied research.

This paper attempts to put the materials issues confronting MHD in proper perspective through a review of the development status of the overall system on a component-by-component basis. Pressing materials problems are defined and related to high temperature research needed to assist in their solution. Emphasis is placed on materials applications in the MHD generator (electrodes) and heat exchangers as these components present the most demanding service conditions.

21261. Jacobs, V. L.; Davis, J.; Rozsnyai, B. F.; Cooper, J. W. Multiple ionization and x-ray emission accompanying the cascade decay of inner-shell vacancies in Fe, *Phys. Rev. A* **21**, No. 6, 1917-1926 (June 1980).

Key words: electron production; multiple ionization; vacancies; x-ray emission.

A model has been developed which predicts the relative abundances of the differently charged ions and the x-ray emission spectra resulting from the cascade decay of an arbitrary distribution of inner-shell vacancies created in atoms by energetic charged particles or x rays. The multiple-ionization and x-ray production cross sections are defined in terms of the populations of the single- and multiple-vacancy states occurring in the atomic reorganization process. All allowed radiative, Auger, and Coster-Kronig transitions are taken into account in the determination of these populations. The x-ray spectra are classified in terms of characteristic lines which are due to the radiative decay of single vacancies and satellites which are associated with transitions from multiple-vacancy states. Results of calculations are presented for the creation of the initial vacancy distribution by single inner-shell electron ionization of neutral Fe with electrons and photons. Multiple ionization is found to represent only 10% of the total for electron-impact ionization but is predicted to be predominant during K- and L-shell photoionization, in agreement with experimental results obtained for the rare gases. The intensity of the L $\alpha$  satellites is always less than the L $\alpha$  characteristic line intensity for electron-impact ionization but can substantially exceed the characteristic line intensity during K-shell photoionization, in agreement with previous results obtained for medium-Z elements.

21262. Bunding, K. A.; Bell, M. I.; Durst, R. A. The surface-enhanced Raman spectrum of N-methylpyridinium ion on a silver electrode, *Chem. Phys. Lett.* **89**, No. 1, 54-58 (June 4, 1982).



Key words: adsorption; electrode processes; N-methylpyridinium iodide; pyridine derivatives; Raman spectroscopy; silver electrode; surface-enhanced Raman spectroscopy.

The SER spectrum is reported for N-methylpyridinium iodide, an organic cation with no unshared electron pair available for interaction with the electrode. Both Raman- and infrared-active bands are observed with small frequency shifts. No SERS is observed for N-methylpyridinium chloride until trace amounts of iodide are added to the solution.

21263. Schaefer, R. J.; Boettinger, W. J.; Biancanello, F. S.; Coriell, S. R. Controlled rapid solidification by electron beam surface melting, (Proc. Symp. 110th AIME Annu. Meet., Chicago, IL, Feb. 22-26, 1981), Paper in *Lasers in Metallurgy*, K. Mukherjee and J. Mazumder, eds., pp. 43-52 (The Metallurgical Society of AIME, P.O. Box 430, 420 Commonwealth Drive, Warrendale, PA 15086, 1981).

Key words: aluminum-silver alloys; cellular growth; electron beam; interface velocity; rapid solidification; stability; surface melting.

The use of a modified electron beam welding apparatus to produce controlled rapid solidification is described. For research purposes, electron beam heating has several advantages over laser heating, most significantly that the absorbed power is known better and the beam can be deflected electronically at high speed. Experiments can thus be carried out in which local solidification velocities can be determined from the known thermal input by means of heat flow calculations. We report here several methods of utilizing electron beam heating, and some observations of cellular substructures in surface melted Al-Ag alloys.

21264. Hill, J. E.; Fanny, A. H. A proposed procedure of testing for rating solar domestic hot water systems, *ASHRAE Trans.* 86, 805-822 (1980).

Key words: energy; heat transfer; hot water; measurement; rating; solar; standards; testing.

A procedure of testing for rating solar domestic hot water (SDHW) systems is currently under consideration by a project committee of the ASHRAE Standards Committee. The procedure requires that the entire SDHW system be assembled in the laboratory and that the system be subjected to specific diurnal variations of the environmental conditions controlling the system performance, such as incident solar radiation and ambient temperature, while the system supplies hot water at specified temperature, times, and draw rate throughout the day. The test continues until the system performance is near-identical for successive days. It is proposed that the rating be the daily "fractional energy savings" under this quasi-steady-state condition. The actual collector array can be used and irradiated with a solar simulator. Alternately, the collector module comprising the array can be tested separately following ASHRAE Standard 93-77, the results used to compute the thermal output of the array under the specified system test conditions, and this thermal output supplied to the system during the system test using a conventional energy source.

The purpose of this paper is to describe the proposed test procedure, suggest alternate ways the simulation of the collector array thermal output can be accomplished in the laboratory, and report on progress being made at the National Bureau of Standards to validate the procedure.

21265. Wood, H. M. Network protocol standards: The U.S. Government approach, *J. Telecommun. Networks* 1, No. 2, 189-190 (1982).

Key words: computer networks; distributed data; Government and industry; protocol standards; telecommunications.

This paper briefly describes the network protocol program carried out by the Institute for Computer Sciences and Technology at the National Bureau of Standards.

21266. Laug, O. B. Two compact meters for field surveys of appliance usage, (Proc. 1978 IEEE Appliance Technical Conf., Columbus, OH, May 16-17, 1978), *Appliance Eng.* 35, No. 8, 70-73 (Aug. 1978).

Key words: counter; timer; watt-hour meter.

Two separate compact instruments have been designed for obtaining appliance usage information in the home: a watt-hour energy meter and an in-line timer and counter for measuring elapsed time and number of use cycles. Part of the uniqueness of these meters is in their compactness. Conventional induction-type energy meters used in surveys are often considered obtrusive when they are located in living areas beside the appliance being monitored. The compact meter for this application is all electronic and equivalent to a 120 V 2-wire single phase induction meter.

The in-line timer/counter was designed to obtain usage information of various 120 V appliances in the home. The small box plugs directly into a wall receptacle. The appliance to be monitored is plugged into a receptacle on the box. No modification or wiring to the appliance is necessary. When the appliance is turned on the elapsed time indicator is activated and the cycle counter is incremented.

21267. Lashmore, D. S. AES research project 41: Plating on anodized aluminum, *Plating Surf. Finish.* 68, No. 4, 48-54 (Apr. 1981).

Key words: aluminum; anodizing; electrodeposition; nickel adhesion; plating.

The effect of anodizing voltage on adhesion of nickel electrodeposited onto anodized aluminum will be discussed and related to the morphology of the anodic film. It is shown that, in general, adhesion is a linear function of the applied anodizing voltage. The morphology of the anodic film is discussed and new data on the initial stages of pore formation presented. In particular, it is shown that the growth mechanism during the initial stage (<10 seconds) is different from subsequent growth, that there is no metallic bonding, and that electrodeposited nickel coatings typically fill the entire pore.

21268. Hubbard, C. R.; Himes, V. L.; Mighell, A. D.; Page, S. W. (3-chloro-2-hydroxy-5-nitrophenyl) (2'-chlorophenyl)iodonium hydroxide, inner salt, *Acta Crystallogr.* B36, 2819-2821 (1980).

Key words: crystal structure; inner salt; iodonium compound; ionic bonding; reaction intermediate; x-ray diffraction.

$C_{12}H_6Cl_2INO_3$ ,  $M_r=410.00$ , monoclinic,  $P2_1/n$ ,  $a=15.928$  (9),  $b=4.623$  (2),  $c=18.271$  (6) Å,  $\beta=105.58$  (2)°,  $Z=4$ ,  $D_x=2.101$ ,  $D_m=2.11$  Mg m<sup>-3</sup>;  $R$  on  $F^2=0.055$  (2302 unique reflections). The molecule exists as a zwitterion with an intramolecular  $I^+...O^-$  distance of 2.755 (4) Å. The I-C bond distances were found to be 2.106 (6) and 2.105 (5) Å, with a C-I-C angle of 98.4 (2)°. Intermolecular ionic attraction between  $I^+$  and  $O^-$  causes the formation of infinite chains along the  $y$  axis of the cell.

21269. Hubbard, C. R.; Stalick, J. K.; Mighell, A. D. NBS\* AIDS80: A FORTRAN program to evaluate crystallographic data, *Adv. X-ray Anal.* 24, 99-109 (1981).

Key words: crystallography; data analysis; determinative ratios; FORTRAN program; metric symmetry; reduced cell.

Techniques for the computer-assisted evaluation of crystallographic data have been developed to improve the data compilations of the NBS Crystal Data Center and the JCPDS—International Centre for Diffraction Data. The resulting computer program, NBS\* AIDS80, can be used for the analysis of unit-cell and powder data by the general scientific community as well. NBS\* AIDS80 is written in FORTRAN to permit implementation on a wide variety of computers, and input may be from cards or from a terminal. The research and analysis components that will be of use to the individual scientist include the following: (1) Calculation of the Crystal Data cell, determinative ratios, and space group for the comparison and reporting of unit cell parameters in a standard setting and for the identification of unknowns. (2) Determination of the reduced cell, reduced form number, and the unit cell with the highest metric symmetry. (3) Calculation of the molecular weight from the formula using the most recent atomic weights, and comparison of the density calculated by the program with the measured density. (4) Generation of d-spacings and indices for any input cell and crystal system. (5) Comparison of input powder data with calculated d-spacings, indexing of lines based on known unit cell parameters, and calculation of figures of merit.



21270. Koll, M. B.; Hardgrave, W. T.; Salazar, S. B. **Data model processing**, *Proc. Natl. Computer Conf. 1982, Houston, TX, June 7-10, 1982*, pp. 571-578 (AFIPS Press, Arlington, VA, 1982).

**Key words:** database management systems; data models; DBMS simulation; positional set notation; set-theoretic.

The Data Model Processor (DMP) is an interactive tool for defining and evaluating data models. It is based on Positional Set Notation, a formalism for uniform representation of data modeling objects. The DMP allows the user to enter a set-theoretic description of a data model's structures and a definition of the model's primitive operations based on positional set operations. Based on the data model definition, the DMP then emulates a database management system (DBMS) implementing that data model. It allows the user to play various roles associated with a DBMS, such as database definer and end user.

This paper gives an overview of the DMP and discusses its foundations, namely, Positional Set Notation and a Positional Set Processor. It traces an example showing how the DMP has been used to model the relational data model. (Hierarchical and network models have also been implemented on the DMP.) Future applications of the DMP are considered.

21271. Hubbard, C. R.; McCarthy, G. J.; Foris, C. M. **PDF workbook: Use of the x-ray powder diffraction file**, *Book: JCPDS*, 48 pages (International Centre for Diffraction Data, 1601 Park Lane, Swarthmore, PA 19081, 1980).

**Key words:** crystal data; diffraction; Hanawalt search procedure; powder diffraction file; x ray.

The workbook is intended as a handout at JCPDS-International Centre for Diffraction Data sponsored Workshops on how to use the Powder Diffraction File. The workbook contains rules of nomenclatures, schematics of search procedures, examples and problems. The examples and problems of the workbook are coordinated with the book *Powder Diffraction Data from the JCPDS Associateship at the National Bureau of Standards*.

21272. Jewett, K. L.; Brinckman, F. E. **Speciation of trace di- and triorganotins in water by ion-exchange HPLC-GFAA**, *J. Chromatogr. Sci.* **19**, 583-593 (Nov. 1981).

**Key words:** biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds.

A broad range of organotins representing current industrial and environmental interests were speciated in trace quantities by a combination of an element-specific graphite furnace atomic absorption (GFAA) detector coupled with high performance liquid chromatography (HPLC) employing commercial, bonded-phase, strong cation-exchange (SCX) columns. Optimization of SCX column parameters was characterized in terms of efficiency and resolution, to provide examples for separation of organotins,  $R_nSn^{(4-n)+}$ , by class ( $n=2,3$ ), functionality ( $R$ =aryl, alkyl, alicyclic), and as geometric isomers ( $R$ =*n*-butyl vs. *i*-butyl; benzyl vs. 4-tolyl). This permitted a novel application of molecular substituent parameters available from the literature in a linear relationship to the free energy term,  $\ln k$ . Means for predicting optimal chromatographic conditions or for identifying unknown  $R$  groups were shown. SCX column performance varied for individual organotin analytes, as did HPLC-GFAA system detection limits (95% confidence limit) in the range 5 to 30 ng (as tin). Applications of the method to current problems involving direct speciation of organotins in field samples from marine antifoulant leachates were described.

21273. Hougen, J. T.; Mucha, J. A.; Jennings, D. A.; Evenson, K. M. **Far infrared laser magnetic resonance spectrum of CH**, *J. Mol. Spectrosc.* **72**, 463-483 (1978).

**Key words:** CH; far infrared; hyperfine constants; lambda doubling; laser magnetic resonance; rotational levels; Zeeman effect.

Laser magnetic resonance spectra between 0 and 17 kG have been

recorded and analyzed for  $(J' \leftarrow J'') = (7/2 \leftarrow 5/2)$ ,  $(5/2 \leftarrow 3/2)$ , and  $(3/2 \leftarrow 1/2)$  transitions in the CH molecule, using the optically pumped far infrared lasers: 118.8  $\mu\text{m}$  ( $\text{CH}_3\text{OH}$ ), 180.7  $\mu\text{m}$  ( $\text{CD}_3\text{OH}$ ), 554.4  $\mu\text{m}$  ( $\text{CH}_2\text{CF}_2$ ), 561.3  $\mu\text{m}$  ( $\text{DCOOD}$ ), and 567.9  $\mu\text{m}$  ( $\text{CH}_2\text{CHCl}$ ). Other transitions in CH were detected with the  $^{13}\text{CH}_3\text{OH}$  laser at 115.8, 149.3, and 203.6  $\mu\text{m}$ . The CH radical was generated in a low-pressure methane and atomic fluorine flame within the laser cavity. Analysis of the  $M' \leftarrow M''$  structure yields wavenumbers for the rotational transitions mentioned above of 84.3494, 55.3397, and 17.8376  $\text{cm}^{-1}$ , respectively. Combining results from the  $M_j$  analysis with the  $J=1/2$   $\Lambda$ -doubling interval derived from radioastronomy measurements yields  $\Lambda$ -doubling values for the  $J=3/2$ ,  $5/2$ , and  $7/2$  states of 0.0237, 0.1620, and 0.3759  $\text{cm}^{-1}$ , respectively. Both the rotational intervals and the  $\Lambda$ -doublings are in good agreement with earlier less precise optical results. Analysis of the hyperfine structure yields values for the Froesch and Foley hyperfine parameters of  $a=+52$ ,  $b=-74$ ,  $c=+52$ , and  $d=+43.6$  MHz, in good agreement with recent *ab initio* estimates and radioastronomy measurements.

21274. Whiting, E. E.; Schadee, A.; Tatum, J. B.; Hougen, J. T.; Nicholls, R. W. **Recommended conventions for defining transition moments and intensity factors in diatomic molecular spectra**, *J. Mol. Spectrosc.* **80**, No. 2, 249-256 (Apr. 1980).

**Key words:** diatomic molecules; intensity factor; notation conventions; rotational line strengths; transition moments.

Two recommendations are made that can eliminate persistent confusion in the study of diatomic spectroscopy by providing uniform and consistent definitions of the electronic transition moments and the rotational line intensity factors. First, it is recommended that the equation for the line strength of a *single rotational line* be adopted to specify the relationship between the electronic transition moment and the rotational line intensity factor. Second, it is recommended that the electronic transition moment operator for perpendicular transitions be defined by  $(1/2^{1/2})(\mu_x \pm i\mu_y)$ . The adoption of these conventions results in a value of  $(2S+1)(2J+1)$  for the sum rule of the rotational line intensity factor for  $\Sigma^+ \leftrightarrow \Sigma^+$  transitions and a value of  $2(2S+1)(2J+1)$  for the sum rule for all other spin-allowed transitions.

21275. Huggett, C. **Measurement and meaning of flame retardancy**, *Proc. Workshop Flammability of Solid Polymer Cable Dielectrics, Americana Inn, Colonie, NY, Oct. 20, 1977*, pp. 8-1-8-8 (Electric Power Research Institute, Palo Alto, CA 94303, Nov. 1979).

**Key words:** fire modeling; fire retardancy; fire tests; flame retardancy; oxygen index test.

Various definitions of flame retardancy and fire retardancy are considered. It is concluded that, for the present purpose, fire retardancy is "the property of a combustible material which reduces destruction by fire." This definition leads directly to a method of measuring fire retardance—full scale fire testing of prototypes. The limitations of such a method are discussed and the possibility of using laboratory scale property measurements to predict fire performance are explored. Such methods are of limited use because they frequently fail to simulate the environment of real fires and because they do not adequately represent the dynamics of fire growth. Mathematical modeling is suggested as a means of bridging the gap between laboratory measured properties of materials and fire performance. It is concluded that appropriately chosen small scale tests can guide product development, but at the present time the safety of a design must be confirmed by full scale prototype tests.

21276. Jones, F. E. **Simplified equation for calculating the refractivity of air**, *Appl. Opt.* **19**, No. 24, p. 4129 (Dec. 15, 1980).

**Key words:** air density; index of refraction of air; refractivity of air; wavelength of light in air.

The simplified equation for the calculation of the refractivity of air derived by combining the air density equation of Jones, Edlén's dispersion formula for standard air, and Edlén's empirically-derived expressions for the effects of  $\text{CO}_2$  abundance and water vapor partial pressure, is presented. The agreement between the simplified equation and Edlén's formulation, under ambient conditions typical of metrology laboratories, is well within the uncertainty in each.

21277. Jones, F. E.; Brickenkamp, C. S. **Calculation of solvent-water**



Key words: Karl Fischer titration; methanol-water mixtures; solvent contraction; solvent-water mixtures; water determination; water extraction.

A procedure has been developed which enables calculation of the ratio of the volume of a solvent-water mixture to the sum of the volumes the components would occupy separately. Expressions have been derived for the general case, and have been applied to the determination of water by Karl Fischer titration of water extracted from various substances into methanol which is then introduced into a titration vessel volumetrically from calibrated syringes.

**21278.** Klebanoff, P. S.; Frenkiel, F. S. Further measurements on the small-scale turbulence structure, *Proc. Second Bat-Sheva Int. Seminar MHD Flows and Turbulence, Beersheva, Israel, Mar. 28-31, 1978*, H. Branover and A. Yakhot, eds., pp. 325-328 (Israel Universities Press, Jerusalem, 1978).

Key words: higher-order moments; hot-wire anemometry; lognormal; small-scale turbulence; velocity gradients.

An experimental investigation of the small-scale turbulence structure is described under conditions which permit an extended Reynolds number range to be obtained without altering the flow configuration. Measurements of higher-order moments of temporal gradients of the longitudinal and transverse components of the turbulent velocity are presented, and the adequacy of the lognormal representation is evaluated.

**21279.** Hsu, S. M. Review of laboratory bench tests in assessing the performance of automotive crankcase oils, *Lubr. Eng.* **37**, No. 12, 722-731 (Dec. 1981).

Key words: automotive crankcase oils; bench test procedures; catalysts; correlation; dispersancy; engine sequence tests; hot tube; laboratory bench tests; oxidation; solubilization.

The basic mechanisms of how a lubricant degrades in an engine are not well understood. Most of the bench tests are developed empirically based on engine test and product development experience. Very few test procedures are published in the open literature and, therefore, the degree of correlation between various bench tests and engine tests is difficult to assess. A large body of information of bench test procedures, however, can be found in the patent literature in which bench tests are often used to substantiate claims. This review will focus on various test procedures in several performance areas and attempt to summarize the current state of art in bench testing based on available information in the public domain.

**21280.** Hoffman, J. D.; Guttman, C. M.; DiMarzio, E. A. On the problem of crystallization of polymers from the melt with chain folding, *Faraday Discuss. Chem. Soc.* **68**, 178-197 (1979).

Key words: chain folding; crystallization of polymers; lamellae.

It is shown that the "reptation" process proposed by deGennes allows molecules to be reeled from the melt onto the crystal surface with chain folding by the force associated with crystallization at a rate that is comparable to that demanded by the observed crystallization kinetics for polyethylene fractions  $n$ =number of C atoms=1290 to 5310. Hence, the rate of transport in the melt is sufficient to permit a considerable amount of chain folding, and an objection due to Flory and Yoon is thereby countered for the range of  $n$  noted. The deductions of Yoon and Flory from the neutron scattering data of Schelten and coworkers on PEH/PED mixtures ( $\eta_{PED} \approx 3750$ ) quench-crystallized from the melt are considered next. It is shown that Yoon and Flory's favored  $p_{es} = 0.3$  model, which gives a probability of adjacent re-entry  $p_{ar}$  close to zero, is deficient despite the good fit of the scattering data since it exhibits a large density anomaly in the region between the crystal lamellae. This opposes their own view that the material in the interlamellar region has essentially normal amorphous state properties. A "central core" model is proposed that does not possess a density anomaly, and which predicts the scattering curve, characteristic ratio, and crystallinity with fair accuracy. This and certain other models give  $p_{ar} \sim 0.65$ , indicating that the adjacent position is by a considerable margin the most probable site for re-entry, in contrast to the analysis of Yoon and Flory. The core model exhibits a mean throw distance of  $\sim 22 \text{ \AA}$  for

the non-adjacent re-entry loops. This is comparable to the mean "niche" distance calculated from nucleation theory. The number of ties between the lamellae is less than one per chain. Hence the connections of this type between the lamellae are less profuse than have sometimes been depicted.

**21281.** Agarwal, G. S.; Haan, S. L.; Burnett, K.; Cooper, J. Influence of spontaneous emission on laser-induced autoionization, *Phys. Rev. Lett.* **48**, No. 17, 1164-1167 (Apr. 26, 1982).

Key words: laser induced autoionizations; photoelectron spectra.

A master equation that describes the effect of spontaneous emission on laser-induced autoionization is formulated and its solution is obtained for arbitrary laser strengths. The radiative decay is shown to affect drastically the nature of spectra near confluence. Analytic expressions for widths and positions are given to demonstrate the new features of spectra.

**21282.** Hastie, J. W.; Bonnell, D. W.; Plante, E. R. Slag and metal oxide vaporization in reactive atmospheres, *High Temp. Sci.* **13**, 257-277 (1980).

Key words: Knudsen effusion; mass spectrometry; slag vaporization; transpiration.

Metal oxides, whether they are present in the form of refractory ceramics or slags, are key components of high temperature energy systems. Planned magnetohydrodynamic (MHD) and coal gasifier systems are particularly dependent on the thermochemical properties of ceramic and slag materials. However, almost no basic thermochemical data exist for oxides in the presence of high temperature-high pressure reactive gases such as  $H_2O$ . The present study utilizes a modification of the now classical Knudsen effusion mass spectrometric technique and a new technique, transpiration mass spectrometry, for molecular-level thermochemical analysis of  $MgO$  and a potassium enriched MHD coal slag in the presence of  $H_2O$  vapor and related gases. New data are presented for the enthalpy of formation of  $M_2OH$  ( $\Delta H_{f,298} = -35.8 \pm 3.0 \text{ kcal/mol}$ ). Species partial pressures and derived activity coefficients are given for a potassium enriched Illinois number 6 coal slag over a range of  $K_2O$  content (15.4-8.0 mol%) and temperature (1100-1820 K). Data on the effect of  $H_2O$  vapor on alkali vapor transport are also given.

**21283.** Haus, J. W.; Raveché, H. J. Computer studies of dynamics in one dimension: Hard rods, *J. Chem. Phys.* **68**, No. 11, 4969-4976 (June 1, 1978).

Key words: distribution functions; hard rods; molecular dynamics; non-ergodic; relaxation; velocity autocorrelation.

Results of molecular dynamics simulations are reported with emphasis on the relaxation of an initially ordered array of hard rods in one dimension. It is found that at high densities the pressure accurately approaches the exact value for the infinite system, which corresponds to a uniform fluid, before the singlet and pair configuration space distribution functions have completely relaxed to the equilibrium state. The velocity autocorrelation function is computed over a wide range of times, which includes the region where it is negative, and compared to the exact solution for the infinite system.

**21284.** Allan, D. W.; Barnes, J. A. A modified "Allan Variance" with increased oscillator characterization ability, *Proc. 35th Annu. Frequency Control Symp., May 27-29, 1981*, pp. 470-475 (Electronic Industries Association, 2001 Eye Street, NW., Washington, DC 20006).

Key words: flicker noise; frequency stability; oscillator noise modeling; power law spectra; time-domain stability; white noise.

Heretofore, the "Allan Variance,"  $\sigma_y^2(\tau)$ , has become the de facto standard for measuring oscillator instability in the time-domain. Often oscillator frequency instabilities are reasonably modelable with a power law spectrum:  $S_y(f) \sim f^{-\alpha}$ , where  $y$  is the normalized frequency,  $f$  is the Fourier frequency, and  $\alpha$  is a constant over some range of Fourier frequencies. It has been shown that for power law spectrum  $\sigma_y^2(\tau) \sim \tau^\mu$ , and that  $\mu = -\alpha - 1$  for  $-3 < \alpha \leq +1$ , where  $\tau$  is the nominal sample time over which each value of  $y$  is measured. The modified "Allan Variance" developed in this paper yields  $\mu \approx -\alpha - 1$  for all  $\alpha$  in



the range  $-3 < \alpha$ , which removes the previous ambiguity:  $\mu = -2$  for  $+1 < \alpha$ . In other words, with the modified "Allan Variance" one can easily distinguish between white phase noise ( $\alpha = +2$ ) and flicker phase noise ( $\alpha = +1$ )—commonly occurring for the short term instabilities of quartz crystal oscillators and active hydrogen masers.

**21285.** Wineland, D. J. Prospects for stored ion frequency standards, (Proc. 13th Annu. Precise Time & Time Interval (PTTI) Applications and Planning Meet., Naval Research Laboratory, Washington, DC, Dec. 1-3, 1981), *NASA Conf. Publ.* 2220, 579-591 (National Aeronautics and Space Administration, Scientific & Technical Information Branch, 400 Maryland Avenue, SW., Washington, DC 20546, 1982).

Key words: atomic clock; atomic frequency standard; atomic spectroscopy; ion storage; spectroscopy; stored ion spectroscopy.

Fundamental limitations of possible frequency standards based on stored ions are examined. Practical limitations are also addressed but without regard to size, power consumption, and cost. With these guidelines, one can anticipate that a stored ion frequency standard with accuracy and stability better than  $10^{-15}$  is now possible.

**21286.** Gadzuk, J. W. A dissipative trajectory theory for reactive scattering at surfaces, *Surf. Sci.* 118, 180-192 (1982).

Key words: sticking; surface reaction dynamics; vibrational spectroscopy.

The Tully-Preston "surface-hopping trajectory model" originally constructed for gas phase reactive-scattering events is adapted to a class of atomic scattering processes at solid surfaces involving a substrate-induced diabatic transition on the incident atom. The role of energy dissipation due to substrate excitations is shown to drastically influence the reaction probability. Within the context of the trajectory theory, dissipation places upper limits on the number of trajectories leading to non-reactive events and hence on the reaction probability. This is illustrated by example, using sticking as a prototypical event. A criterion for large sticking coefficients is given in terms of vibrational frequencies and linewidths and of desorption energies, all quantities being experimentally accessible with current state-of-the-art measurement techniques. An experiment, based on the present theory, is proposed which could differentiate between electronic and phonon dissipation.

**21287.** Hillhouse, D. L.; Sze, W. C. Calibration of CCVTs in the substation, *Proc. 45th Annu. Int. Conf. of Doble Clients, Boston, MA, Apr. 10-14, 1978, Section 9*, pp. 501-509 (1978).

Key words: CCVT; compact; field calibration; high accuracy; modular capacitive divider; portable system; truck-mounted.

A system for calibration of coupling capacitor voltage transformers (CCVTs) in the substation has been developed. It contains a modular transfer standard divider made up of CCVT capacitors, a current comparator bridge, a high voltage standard capacitor, and a resonant power supply, transported and operated from a closed truck. The divider is stacked up and connected to the CCVT bus for the calibration. The system is compact, requires only two operators plus utility crews, and can be assembled and disassembled quickly on site. Accuracy is 0.05% and 0.3 milliradian. It has successfully undergone field tests. Feasibility of a simpler system has been demonstrated in the laboratory.

**21288.** Wacławski, B. J.; Pierce, D. T.; Swanson, N.; Celotta, R. J. Direct verification of hydrogen termination of the semiconducting diamond(111) surface, *J. Vac. Sci. Technol.* 21, No. 2, 368-370 (July/Aug. 1982).

Key words: deuterium on diamond; diamond(111)  $1 \times 1$ ; EELS; electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; surface reconstruction; surface states; vibrational spectra.

Low-energy, high-resolution electron energy loss spectroscopy has been used to identify the vibrational modes of hydrogen on the semiconducting diamond surface providing the first direct evidence that the (111)  $1 \times 1$  surface is terminated by hydrogen. The vibrational loss spectrum from the "as-polished" surface shows two major losses near 160 meV ( $\text{CH}_3$  deformation), a major loss at 360 meV ( $\text{CH}_2$

stretch), and two minor losses at 520 and 720 meV (combinations and overtones). All of these losses disappear from the spectrum after heating the sample to  $\sim 1000^\circ\text{C}$  (which has been established by other experiments to be sufficient to reconstruct the surface to  $2 \times 2/2 \times 1$ ). The loss spectrum for the reconstructed surface is indicative of a two-dimensional metallic state of the dangling-bond surface states for clean diamond. Exposure of this reconstructed surface to atomic hydrogen results in a loss spectrum which is essentially identical to that for the as-polished surface. Further verification that the loss spectrum results from hydrogen is provided by the shift of the structure to lower loss energies when deuterium is absorbed.

**21289.** McIlrath, T. J.; Lucatorto, T. B. Comment on "The effect of radiation trapping of high-intensity scattered radiation on multiphoton ionisation rates and resonance fluorescence", *J. Phys. B: Atom. Molec. Phys.* 13, L641-L644 (1980).

Key words: fluorescence; ionization; laser ionization; metal vapors; radiation trapping; resonance radiation.

Recent claims have been made that the trapping of resonance radiation explains both the efficient ionization of dense metal vapours irradiated by intense resonant laser radiation and previous experiments concerning anomalous behaviour of resonance fluorescence. We examine these claims and show that they are incorrectly developed and that basic physical arguments show that resonance trapping cannot explain the phenomena mentioned above.

**21290.** Lucatorto, T. B.; McIlrath, T. J. Laser excitation and ionization of dense atomic vapors, *Appl. Opt.* 19, No. 23, 3948-3956 (Dec. 1, 1980).

Key words: dense atomic vapors; electrons; ionization; laser excitation; resonant scattering.

It has been shown that a dense ( $> 10^{14}\text{-cm}^{-3}$ ) atomic vapor, irradiated by a saturating pulse of resonance radiation, will ionize on a time scale of  $< 10^{-6}\text{sec}$ . The ionization can be 95% complete and has been observed in Li, Na, Ca, Sr, and Ba. A large number of physical processes contribute to the ionization with different processes dominating at different stages in the ionization. These processes are discussed, and two models for calculating the ionization are described. The results of the various experiments and the applications to the spectroscopy of ions and to atomic physics studies in general are reviewed.

**21291.** Ederer, D. L.; Parr, A. C.; West, J. B.; Holland, D.; Dehmer, J. L. Measurement of the spin-orbit branching ratios and the angular asymmetry parameter in the region of the  $4s4p^65p$  resonances in krypton and the  $5s5p^66p$  resonances in xenon, *Phys. Rev. A* 25, No. 4, 2006-2011 (Apr. 1982).

Key words: asymmetry parameter; autoionization; branching ratios; innershell resonances; photoelectron spectroscopy; rare gases; synchrotron radiation.

Variation of the ratio of partial photoionization cross sections  $R = \sigma^2(P_{3/2})/\sigma^2(P_{1/2})$  and the asymmetry parameter  $\beta$  have been determined in the region of the  $4s4p^65p$  resonances in krypton and  $5s5p^66p$  resonances in xenon. In both cases these resonances are affected by the interaction with a configuration involving two excited outer  $p$  electrons. This admixture influences the number of resonances present, and the value of  $\beta$  and  $R$ . Large variations in  $\beta$  and  $R$  are observed in the region of these resonances.

**21292.** Parr, A. C.; Ederer, D. L.; Dehmer, J. L.; Holland, D. M. P. Characterization of some autoionization resonances in  $\text{CO}_2$  using triply differential photoelectron spectroscopy, *J. Chem. Phys.* 77, No. 1, 111-117 (July 1, 1982).

Key words: angular distributions; photoelectron spectroscopy; photoionization.

We report vibrationally resolved branching ratios and asymmetry parameters for two sets of autoionizing resonances in  $\text{CO}_2$  near 680 and 750 Å. These resonances were excited with monochromatized synchrotron radiation from the National Bureau of Standards storage ring and the energy and angle of ejection of the photoelectrons were analyzed. The results show striking non-Franck-Condon behavior.



**21293.** Dizdaroglu, M.; Krutzsch, H. C.; Simic, M. G. Separation of peptides by high-performance liquid chromatography on a weak anion-exchange bonded phase, *J. Chromatogr.* **237**, 417-428 (1982).

Key words: amino acid analysis; anion-exchange; cytochrome c; enzymatic digestion; high-performance liquid chromatography; peptides.

Multicomponent peptide mixtures were separated by high-performance liquid chromatography on a MicroPak AX-10 column, a silica-based bonded-phase weak anion exchanger. A gradient of increasing 0.01 M triethylammonium acetate buffer (pH 6.0) into acetonitrile was usually used for elution. For peptides containing a number of acidic amino acids without compensating basic residues, such as delta sleep-inducing peptide, a dilute 0.04 M formic acid solution (pH 2.6) was employed as the eluent. Peptides of up to about 30 residues were successfully tested, including peptides such as somatostatin, neurotensin, ribonuclease s-peptide,  $\alpha$ -endorphin, glucagon, and various angiotensins and bradykinins. Tryptic digests of horse heart cytochrome c, calmodulin and reduced and alkylated hen egg-white lysozyme were also successfully examined. Because of the volatility of the eluents used, peptides can be readily isolated for further investigation. Recoveries of over 80% were observed in those cases tested by comparative amino acid analysis.

**21294.** Dizdaroglu, M.; Krutzsch, H. C.; Simic, M. G. Separation of angiotensins by high-performance liquid chromatography on a weak anion-exchange bonded phase, *Anal. Biochem.* **123**, 190-193 (1982).

Key words: angiotensins; anion-exchange; high-performance liquid chromatography; hormones; peptides.

A mixture of 12 angiotensins was separated by high-performance liquid chromatography on a weak anion-exchange bonded phase using a triethylammonium acetate buffer and acetonitrile as the eluant. An excellent separation of these compounds was obtained. Recoveries for all 12 were over 90%, as determined by comparative amino acid analysis. A strong effect of temperature on retention was observed. The buffer used here allows sensitive detection of these peptides at wavelengths in the range 210–225 nm. Because the eluents are also volatile, isolation of separated compounds for reuse or further analysis is facilitated.

**21295.** Cavanagh, R. R.; Kelley, R. D.; Rush, J. J. Neutron vibrational spectroscopy of hydrogen and deuterium on Raney nickel, *J. Chem. Phys.* **77**, No. 3, 1540-1547 (Aug. 1, 1982).

Key words: chemisorption; hydrogen; neutron inelastic scattering; Raney nickel; vibrational spectroscopy.

Incoherent neutron inelastic scattering has been applied to the study of the chemisorption of hydrogen and deuterium on Raney nickel (a high surface area nickel powder). The binding sites have been identified by comparing the vibrational frequencies and intensities provided by the inelastic scattering with calculations for model structures of different geometries, force constants, and symmetries. We conclude that, on Raney nickel above 150 K, hydrogen chemisorbs predominantly in sites of threefold symmetry. The "best fit" corresponds to a Ni-H bond distance of  $1.88 \pm 0.03$  Å and a force constant of  $0.58 \pm 0.03$  mdyn/Å. In addition, we have observed lateral adsorbate interactions, deuterium isotope shifts, and temperature dependent binding sites.

**21296.** Hanson, D. M.; Stockbauer, R.; Madey, T. E. The interaction of methanol with a titanium(001) surface investigated using photon stimulated desorption and UV photoemission spectroscopy, *J. Chem. Phys.* **77**, No. 3, 1569-1575 (Aug. 1, 1982).

Key words: hydrogen; methanol; methoxy; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS.

Synchrotron radiation at NBS SURF II has been utilized to study the interaction of methanol with a stepped Ti(001) single crystal surface at about 90 and 300 K. The techniques of photon stimulated desorption (PSD) and UV photoemission spectroscopy (UPS) were employed. Exposure of the clean surface at 300 K to methanol initially results in dissociative adsorption with features indicative of C, O, and H appearing in UPS. At higher exposures, features that have been identified as being characteristic of a methoxy species appear. At

90 K, this species is found to be present even at low exposures, and there is little, if any, further dissociation. Multilayers of methanol are then formed at higher exposures. PSD of ions from the condensed methanol multilayers was observed using photon energies from 15 to 75 eV with a maximum yield at about 25 eV. Using electron stimulated desorption and time of flight mass spectroscopy, the ions were identified as  $H^+$ . Partial photoionization yields as a function of photon energy were measured for comparison with the PSD yield spectrum. No PSD was detected from the methoxy species.

**21297.** Himes, V. L.; Mighell, A. D.; Siedle, A. R. Synthesis and structure of  $Cu_2(BTA)_6(\textit{t}\text{-}C_4H_9NC)_4$ , a mixed-valent copper-nitrogen cluster containing  $\eta^3$ -benzotriazolate, *J. Am. Chem. Soc.* **103**, 211-212 (Jan. 14, 1981).

Key words: azometallocycle; benzotriazole anion; copper complex; corrosion inhibitor; crystal structure; single crystal x-ray diffraction; tridentate ligand.

$C_{56}H_{60}Cu_5N_{22}$ , MW=1359, tetragonal,  $P4_2c$ ,  $a=13.836$  (4) Å,  $c=16.686$  (4) Å,  $Z=2$ ,  $D_{\text{calcd}}=1.413$ ,  $D_{\text{obsd}}=1.41$  (2) Mg m<sup>-3</sup> (flotation),  $\mu(\text{Mo } K\alpha)=16.9$  cm<sup>-1</sup>,  $R=0.063$  (903 observed reflections). The structure solution revealed a unique tridentate bonding mode for the benzotriazole anion (BTA<sup>-</sup>). The structure consists of neutral 3-dimensional complexes with crystallographic  $\bar{4}$  symmetry. A central Cu(II) ion is coordinated to six different BTA<sup>-</sup> ligands in an undistorted, compressed octahedral configuration. The Cu(II) ion is surrounded by four Cu(I) ions each of which is tetrahedrally coordinated to three different BTA<sup>-</sup> ligands and one *t*-butylisocyanide ligand. The six BTA<sup>-</sup> ligands bridge each Cu(I) ion to three symmetry-related Cu(I) ions and to the central Cu(II) ion.

**21298.** Himes, V. L.; Mighell, A. D.; De Camp, W. H. Structure of carbamazepine: 5*H*-dibenz[*b,f*]azepine-5-carboxamide, *Acta Crystallogr.* **B37**, 2242-2245 (1981).

Key words: analgesic; anticonvulsant; azepine ring; carbamazepine; crystal structure; molecular structure; USP reference standard; x-ray diffraction.

$C_{15}H_{12}N_2O$ ,  $M_r=236.27$ , monoclinic,  $P2_1/n$ ,  $a=7.537$  (1),  $b=11.156$  (2),  $c=13.912$  (3) Å,  $\beta=92.86$  (2)°,  $Z=4$ ,  $D_m=1.34$  (2) (flotation),  $D_x=1.343$  Mg m<sup>-3</sup>,  $\mu(\text{Mo } K\alpha)=0.080$  mm<sup>-1</sup>;  $R=0.040$  for 1751 observed reflections. In the tricyclic framework of carbamazepine, the central azepine ring has a boat conformation and the dihedral angle between the planar benzene moieties is 126.6°. Intermolecular hydrogen bonding between carboxamide groups forms centrosymmetric dimers. (CAS Reg. No. 298-46-4.)

**21299.** Julienne, P. S.; Krauss, M. Role of the III(1/2)-II(1/2) transition in rare-gas-halide kinetics, *Appl. Phys. Lett.* **35**, No. 1, 55-57 (July 1, 1979).

Key words: excimer lasers; fluorescence branching ratios; kinetics; rare gas halides; rate coefficients.

Rare-gas-halide spectra have previously been analyzed in terms of the strong III(1/2)-I(1/2) lasing transition and the weaker II(3/2)-I(3/2) broad continuum. However, the III(1/2)-II(1/2) transition is also a broad continuum that strongly overlaps the II(3/2)-I(3/2) transition and has an Einstein coefficient of a similar magnitude. The existence of this transition requires a reinterpretation of previous kinetic data on ArF, KrF, XeF, and XeCl. Simultaneous energy extraction from both the III(1/2) and II(3/2) states should be possible for lasing in the broad continuum.

**21300.** Weber, A. Rovibronic species, overall allowed species, and nuclear spin statistical weights for symmetric top molecules. II. Point groups  $C_{nv}$  and  $C_{nh}$  ( $n \leq 6$ ), *J. Chem. Phys.* **76**, No. 7, 3694-3698 (Apr. 1, 1982).

Key words: group theory; nuclear spin; rovibronic species; statistical weights; symmetric top molecules.

The method described in I [A. Weber, *J. Chem. Phys.* **73**, 3952 (1980); **74**, 4754 (1981)] has been used to derive the rovibronic species, overall allowed species, and the nuclear spin statistical weights for symmetric top molecules belonging to the point groups  $C_{nv}$  or  $C_{nh}$  with  $n \leq 6$ . Rules are presented by means of which the rovibronic species of  $C_{nv}$  and  $C_{nh}$  molecules are obtained from the results given in



I. The overall species and the nuclear spin statistical weights are given in a new set of tables.

**21301.** Jacox, M. E.; Rook, F. L. Photodecomposition of methyl nitrite trapped in solid argon, *J. Phys. Chem.* **86**, No. 15, 2899-2904 (July 22, 1982).

Key words:  $\text{CH}_3\text{O}$ ; formaldehyde;  $\text{HNO}$ ; hydrogen bonding; infrared spectrum; matrix isolation; methyl nitrite; photodecomposition.

The threshold wavelength for the photolysis of methyl nitrite isolated in solid argon at 14 K has been determined to be near 370 nm. Photolyzed samples show prominent infrared absorptions of  $\text{H}_2\text{CO}$  and  $\text{HNO}$ , which are perturbed by the hydrogen-bonding interaction of these two molecules trapped in adjacent sites. In studies with 122- and 105-nm radiation sources and with concurrent deposition and photolysis, some of the  $\text{H}_2\text{CO}$  escapes interaction with  $\text{HNO}$ . Similar observations result on photolysis of methyl- $d_3$  nitrite. Time dependence studies show that in the early stages of photolysis the *trans*- $\text{CH}_3\text{ONO}$  absorptions grow at the expense of those of the *cis* rotamer. The stabilization of  $\text{H}_2\text{CO}$  and  $\text{HNO}$  is consistent with gas-phase observations, which have demonstrated that the primary products of the photodecomposition of both *cis*- and *trans*- $\text{CH}_3\text{ONO}$  are  $\text{CH}_3 + \text{NO}$ , which can recombine with zero activation energy either to re-form  $\text{CH}_3\text{ONO}$  or to form  $\text{H}_2\text{CO} + \text{HNO}$ . The cage recombination of  $\text{CH}_3\text{O}$  and  $\text{NO}$  to form these same products should predominate in the decomposition of methyl nitrites in other condensed-phase systems. The possible deactivation of electronically excited methyl nitrite into lower electronic states or into excited vibrational levels of the ground electronic state which favor direct decomposition into  $\text{H}_2\text{CO} + \text{HNO}$  is considered.

**21302.** Rook, F. L.; Jacox, M. E. The vibrational spectra of methyl and methyl- $d_3$  nitrite, *J. Mol. Spectrosc.* **93**, 101-116 (1982).

Key words: force constants; gas phase; infrared spectrum; matrix isolation; methyl- $d_3$  nitrite; methyl nitrite; nitromethane; photolysis.

The infrared spectra of methyl and methyl- $d_3$  nitrite have been observed between 400 and  $4000\text{ cm}^{-1}$  both in the gas phase and in an argon matrix. The very strong absorptions associated with the vibrations of the  $\text{ONO}$  group have also been observed for the carbon-13 and nitrogen-15 substituted methyl nitrites, produced by the photolysis of the corresponding nitromethane isolated in solid argon. The assignment of individual bands to the *cis* and *trans* rotamers has been facilitated by studies of the relative rates of photolysis of the two species trapped in solid argon. The vibrational assignments for the two rotamers are discussed in relation to a least-squares fit of the observed vibrational frequencies to a relatively simple set of valence force potential constants.

**21303.** Maki, A. G.; Lovas, F. J.; Olson, W. B. Infrared frequency measurements on the  $\text{ClO}$  fundamental band, *J. Mol. Spectrosc.* **92**, 410-418 (1982).

Key words: air pollution; atmospheric chemistry; chlorine monoxide;  $\text{ClO}$ ; diode laser; infrared; spectra.

By means of a tunable diode laser, new frequency measurements have been made on the 1-0 band of  $^{35}\text{ClO}$  and  $^{37}\text{ClO}$  in the region from 829 to  $881\text{ cm}^{-1}$ . The new measurements are calibrated against recently measured  $\text{OCS}$  absorption frequency standards. Measurements of more than 40 1-0 band transitions are combined with 2-0 band measurements and with the results of microwave measurements in a least-squares analysis. The Hamiltonian used for the analysis takes into account the coupling between the  $^2\Pi_{1/2}$  and  $^2\Pi_{3/2}$  states and includes the dependence of the molecular parameters on the reduced mass of the molecule. The resulting constants are used to calculate the frequencies of all the stronger absorption lines with an accuracy ranging from  $\pm 0.0002$  to  $\pm 0.0065\text{ cm}^{-1}$ , depending on the transition.

**21304.** Kashiwagi, T. Ignition of a liquid fuel under high intensity radiation, *Combust. Sci. Technol.* **21**, 131-139 (1980).

Key words: absorption;  $\text{CO}_2$  laser; decane; ignition.

The ignition of a liquid fuel under high intensity radiation was studied experimentally to obtain a fundamental understanding of the ignition mechanism and to aid in the selection of design improvements to minimize hazards of unwanted fires. The experiments were conducted using a CW  $\text{CO}_2$  laser with incident fluxes from 1000 to  $5000\text{ W/cm}^2$  and *n*-decane as the flammable liquid. The study of the effect of the container size showed 6 cm diameter by 5 cm depth sufficiently large to prevent container size effects on ignition. High speed photographs of ignition events showed the motion of decane prior to ignition and the onset of the ignition in the gas phase. The effect on ignition of the incident angle of the laser beam with respect to the decane surface was studied from  $90^\circ$  to  $30^\circ$ . On reducing the incident angle, the ignition delay time becomes longer and the minimum incident flux for ignition increases significantly. The proposed autoignition mechanism of decane by a  $\text{CO}_2$  laser is the absorption of the incident laser beam energy by the vapor plume.

**21305.** Kashiwagi, T. Radiative ignition mechanism of solid fuels, *Fire Safety J.* **3**, 185-200 (1979).

Key words: absorption; ignition; polymethylmethacrylate; radiation; red oak; surface temperature.

Transmittance of external radiation from a  $\text{CO}_2$  laser through a boundary layer of decomposition products over a vertical sample surface is measured during the ignition period. The results indicate that there is significant absorption of the external radiation for PMMA, and a lesser but still not negligible amount, for red oak. An increase in gas phase temperature over surface temperature is observed over much of the ignition interval. Using the experimentally measured incident flux at the sample surface, surface temperature history was calculated from a model that included re-radiation and convection losses from the surface, endothermic decomposition and conduction into the material. The results confirm the significant effect of gas phase absorption on surface temperature. Steady-state-derived surface regression rate expression was used for PMMA in this model. The results raise questions about the validity of such data for the dynamic heating conditions during the ignition period. Further studies needed to understand the radiative ignition mechanism are identified.

**21306.** Kashiwagi, T. Effects of attenuation of radiation on surface temperature for radiative ignition, *Combust. Sci. Technol.* **20**, 225-234 (1979).

Key words: ignition; ignition surface temperature; polymethylmethacrylate; radiative ignition; red oak; surface temperature.

The effects of the attenuation of the radiation by the decomposition products in the gas phase on surface temperatures of PMMA and red oak were studied by using a  $\text{CO}_2$  laser in the radiant flux range from 7 to  $18\text{ W/cm}^2$  irradiating normally downward to the horizontally mounted sample. It was observed that the attenuation of the radiation caused by the decomposition products in the gas phase was significant enough to affect surface temperature. Maximum surface temperature of PMMA rises to about  $400^\circ\text{C}$  during the preignition heating period and tends to be independent of the initial radiant flux. Surface temperature at ignition is in the range of  $375$  to  $410^\circ\text{C}$  and remains fairly constant from  $8$  to  $19\text{ W/cm}^2$  for piloted-ignition and auto-ignition. However, the maximum surface temperature of red oak during the preignition heating period tends to increase with the decrease in the initial radiant flux. Surface temperature at ignition increases from  $400^\circ\text{C}$  at  $16\text{ W/cm}^2$  to  $575^\circ\text{C}$  at  $8\text{ W/cm}^2$  for auto-ignition and from  $420^\circ\text{C}$  at  $15\text{ W/cm}^2$  to  $500^\circ\text{C}$  at  $7\text{ W/cm}^2$  for piloted-ignition.

**21307.** Klote, J. H. Stairwell pressurization, *ASHRAE Trans.* **86**, Pt. 1, 604-623 (1980).

Key words: bottom injection; multiple injection; smoke candle test; smoke control; stairwell pressurization; top injection; tracer gas test.

Pressurized stairwells have been used increasingly in the past few years to provide smoke free escape routes. However, there are no accepted design procedures for these systems. This paper provides a discussion of several of the designs currently in use. In particular, single and multiple injection systems are discussed. A report is made on field tests on 5 pressurized stairwells. The testing is part of a continuous program to evaluate alternate systems, in an attempt to



establish design recommendations for the future.

21308. Stevens, W. J.; Krauss, M. The electronic structure and photodissociation of HCl, *J. Chem. Phys.* 77, No. 3, 1368-1372 (Aug. 1, 1982).

Key words: ab initio; electronic structure; multiconfiguration; photodissociation; self-consistent field theory.

Continuous absorption is possible from the ground state of HCl to the repulsive states that also arise from the ground state asymptote. Under conditions where vibrational excitation of the HCl is possible, continuum absorption can occur from an onset near 345 to 100 nm in the ultraviolet. Since the two states  $X^1\Sigma^+$  and  $A^1\Pi$ , that are dipole coupled, correlate to the same asymptote, the transition moment varies rapidly with the internuclear distance. Using all-electron *ab initio* calculations based on multiconfiguration self-consistent field (MC-SCF) and first-order configuration interaction (FOCI), the energy curves and wave functions have been obtained for the  $X^1\Sigma^+$ ,  $a^3\Pi$ ,  $A^1\Pi$ ,  $b^3\Sigma^+$  states, and the first excited states of each symmetry. The electronic structure of the states are analyzed and the energy curves are compared favorably to experiment. Using the calculated  $A-X$  transition moment, the  $A-X$  absorption cross section has been obtained as a function of the ground state vibrational level. The possible impact of this process on the operation of the XeCl UV laser which uses HCl as a fuel would not be significant since the cross section at 310 nm never exceeds a few times  $10^{-19} \text{ cm}^2$ .

21309. Stevens, W. J.; Krauss, M. Absorption in the triatomic excimer,  $\text{Xe}_2\text{Cl}$ , *Appl. Phys. Lett.* 41, No. 3, 301-303 (Aug. 1, 1982).

Key words: blue-green laser; effective core potentials; excimer; rare-gas halide; transition moments.

The equilibrium internuclear geometry has been calculated for the excimer state of  $\text{Xe}_2\text{Cl}$ . At this geometry absorption and emission transition probabilities have been calculated for transitions that bear on the gain of the  $\text{Xe}_2\text{Cl}$  excimer transition and of the  $\text{XeCl}$  C-A transition. The total lifetime of the  $\text{Xe}_2\text{Cl}$  excimer state is found to be 330 ns for a fluorescence peak at 495 nm. Significant absorption is found to peak at 438 nm which would preclude tuning a laser over the entire fluorescence band. A very strong absorption from the  $\text{Xe}_2\text{Cl}$  excimer state is also found at 339 nm which practically coincides with the broadband  $\text{XeCl}$  C-A transition.

21310. Rosenkrantz, M. E.; Krauss, M.; Stevens, W. J. A theoretical investigation of the origins of the green and red spectra of  $\text{Ca}_2$ , *Chem. Phys. Lett.* 89, No. 1, 4-8 (June 4, 1982).

Key words:  $\text{Ca}_2$ ; charge density; electronic spectra; predissociation; transition probability assignment.

The potential energy curves and transition moments of the ground state of  $\text{Ca}_2$  and  $^1\Sigma_u^+$  states correlating with the  $^1S+^1P$  and  $^1S+^1D$  calcium atoms have been calculated. The calculations support the assignment of the observed emission spectra of  $\text{Ca}_2$  in the red and in the green to transitions between the ground state and the  $1,2^1\Sigma_u^+$  states. Predissociation of the  $1^1\Sigma_u^+$  state is also shown to be possible from an interaction with the  $1^3\Pi_u$  state.

21311. Loevinger, R. The role of the standards laboratory in brachytherapy, *Proc. Recent Advances in Brachytherapy Physics*, Sturbridge, MA, Oct. 5-6, 1979, pp. 22-31 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1981).

Key words: brachytherapy; calibration; cesium-137; dosimetry standards; iodine-125; iridium-192; radium; standards.

The role of the standards laboratory in the medical use of brachytherapy (interstitial) sources is to provide access to the International Measurement System by providing calibration against verified national dosimetry standards. It is proposed that in the United States clinical brachytherapy sources shall be calibrated by comparison with sources of the same kind that have been calibrated at the National Bureau of Standards in terms of exposure rate at one meter in air. It is argued that the quantities activity, exposure-rate constant, and equivalent mass of radium are unnecessary in brachytherapy dosimetry, and for reasons of accuracy and economy of effort should be eliminated in favor of exposure rate at one meter in air.

21312. Johnson, R. G.; Behrens, J. W.; Bowman, C. D. Source imaging using neutron pinhole cameras based on position-sensitive proportional counters, *Nucl. Technol.* 55, 724-727 (Dec. 1981).

Key words: associated particles; neutron imaging; neutron sources; pin-hole camera; position-sensitive proportional counter.

A pinhole camera technique has been used to measure the variation in neutron emission intensity over the area of the neutron-producing target of the National Bureau of Standards Electron Linac. The method uses a one-dimensional position-sensitive proportional counter (PSPC) with an intrinsic spatial resolution of 1.0 mm. The pinhole is made in a thick sheet of cadmium and neutron energy ( $<0.3\text{-eV}$ ) selection is achieved by time-of-flight. In a completely separate experiment, the neutron cone obtained from the  $(d,t)$  reaction using the associated-particle technique was imaged by a two-dimensional PSPC. This second measurement demonstrated the use of the two-dimensional detector for imaging high-energy (14-MeV) neutrons.

21313. Himes, V. L.; Mighell, A. D.; Page, S. W.; Stack, M. E. Structure of xanthomegnin, *Acta Crystallogr.* B37, 1932-1935 (1981).

Key words: absolute configuration; crystal structure; dimer; fungal pigment; metabolite of pathogenic fungi; single crystal x-ray diffraction; xanthomegnin.

$\text{C}_{30}\text{H}_{22}\text{O}_{12}$ ,  $M_r=574.49$ , tetragonal,  $P4_32_12$ ,  $a=8.126$  (1),  $c=38.281$  (4) Å,  $Z=4$ ,  $D_m=1.50$  (2) (floatation),  $D_x=1.510$  Mg  $\text{m}^{-3}$ ,  $\mu(\text{Cu K}\alpha)=0.958 \text{ mm}^{-1}$ ;  $R=0.034$  for 1270 observed reflections. X-ray analysis has revealed that xanthomegnin is a naphtho-[2,3-c]pyran-8-yl dimer. A crystallographic twofold axis relates the two halves of the molecule. In each half of the molecule there is one intramolecular hydrogen bond.

21314. Kashiwagi, T. Experimental observation of radiative ignition mechanisms, *Combust. Flame* 34, 231-244 (1979).

Key words: absorption; ignition; radiation; solid fuel.

Radiative ignition experiments were conducted on PMMA and red oak using a  $\text{CO}_2$  laser with incident flux up to about  $20 \text{ W/cm}^2$  under autoignition and piloted ignition in air. The laser irradiated perpendicular to the horizontal sample surface. It was observed that there was strong attenuation of the incident laser radiation by the plume consisting of decomposition products in the gas phase. This was also observed using an electric coil heater as a radiant source. It is postulated that, under autoignition, PMMA ignites by the absorption of the incident radiation by the decomposition products in the gas phase, and red oak by a similar absorption at high-incident flux and at medium flux, aided by high surface temperature acting as an induced pilot.

21315. Cronin, D. J.; Blackburn, D. H.; Haller, W. K. Unusual luminescence behaviour of terbium phosphate glasses, *Nature* 295, No. 5851, 680-682 (Feb. 25, 1982).

Key words: glass; luminescence; melts; oxidation; reduction; terbium.

While preparing a terbium-containing phosphate glass, an intense emission of green light was observed when the melt was poured into a metal mould. This emission was easily visible to the naked eye and was only observed on quenching of the melts. To our knowledge this phenomenon, termed 'cooling-induced luminescence (CIL)', has not previously been reported. Experimental evidence suggests that the CIL may be related to a thermally induced shift in the oxidation-reduction balance in the melt. A similar phenomenon was also observed with europium phosphate melts.

21316. Holdeman, L. B. Josephson effect, *McGraw-Hill Encycl. Sci. Technol.* 5th Edition, pp. 438-441 (McGraw-Hill Book Co., 1982).

Key words: ac Josephson effect; dc Josephson effect; Josephson junctions; superconductivity; supercurrent; tunneling.

This article presents a brief, semitechnical description of the Josephson effect for inclusion in the new edition of the McGraw-Hill Encyclopedia of Science and Technology.



**21317.** Stefani, G.; Camilloni, R.; Dunn, G. H.; Rogers, W. T. Absolute emission cross section for electron-impact excitation of  $\text{Ga}^+$  to the  $4^1P$  level, *Phys. Rev. A* **25**, No. 6, 2996-3002 (June 1982).

Key words: absolute cross section; crossed beams; electron-ion collisions; excitation; Ga II; resonance line.

Crossed beams of electrons and  $\text{Ga}^+$  ions have been used to measure the absolute emission cross section for the process  $e^- + \text{Ga}^+ (4^1S) \rightarrow e^- + \text{Ga}^+ (4^1P)$  from below threshold (8.77 eV) to 400 eV. Total uncertainties at 68% confidence level are typically 16%. The cross section exhibits the sharp onset at a threshold characteristic of positive-ion excitation processes. Evidence of structure is observed from just above threshold to 15 eV. The semiempirical Gaunt-factor formula is in reasonable agreement with the measurements over the energy range measured. A lower limit for the lifetime of the  $4^3P_{0,2}$   $\text{Ga}^+$  metastable state has been established at  $\tau > 0.4$  sec.

**21318.** Faller, J. E.; Guo, Y. G.; Zumbege, M. A. Determination of absolute gravity, *Proc. American Society of Photogrammetry, American Congress on Surveying and Mapping, Denver, CO, Mar. 14-20, 1982*, pp. 63-74 (American Congress on Surveying and Mapping, Falls Church, VA, 1982).

Key words: absolute gravity; geodesy; geophysics; gravity; tectonics.

The status of absolute gravimetry is discussed. A new and easily portable apparatus which has been developed at JILA for the absolute determination of the acceleration of gravity is described. Laboratory tests of this new instrument indicate a measurement accuracy of 6 parts in  $10^9$  is achieved. This corresponds to an equivalent height sensitivity of about 2 cm.

**21319.** Baughcum, S. L.; Leone, S. R. Laser photodissociation of  $\text{Hg}(\text{CH}_3)_2$ : Infrared emission studies of vibrational and rotational excitation in the  $\text{CH}_3$  fragments, *Chem. Phys. Lett.* **89**, No. 3, 183-188 (June 18, 1982).

Key words:  $\text{CH}_3$ ;  $\text{Hg}(\text{CH}_3)_2$ ; laser; photodissociation.

Single-photon dissociation of  $\text{Hg}(\text{CH}_3)_2$  at 248 and 193 nm produces  $\text{CH}_3$  radicals with substantial excitation in the  $\nu_2$  out-of-plane bend and the  $\nu_3$  antisymmetric stretch. At 248 nm the antisymmetric stretch excitation is characterized by a 1200-1500 K rotational temperature and a vibrational distribution  $\nu = 1:\nu = 2:\nu = 3$  of  $1.0:0.2 \pm 0.1:0.05 \pm 0.05$ .

**21320.** Ananthalakshmi, P.; Agarwal, G. S. Spectral characteristics of signals in the optical Hanle effect, *Phys. Rev. A* **25**, No. 6, 3379-3381 (June 1982).

Key words: Hanle effect; radiation-matter interaction.

The results of an earlier investigation by the authors [*Phys. Rev. A* **23**, 2553 (1981)] are extended to study the spectral features of the signals in the optical Hanle effect with regard to the various directions of observations and the polarizations of the emitted and the exciting radiation. The asymmetries in the spectra are found to be critically dependent on each of these parameters.

**21321.** Agarwal, G. S. Dipole radiation in the presence of a phase conjugate mirror, *Opt. Commun.* **42**, No. 3, 205-207 (July 1, 1982).

Key words: dipolar emission; phase conjugacy.

The decay rate of a dipole in the presence of a phase conjugate mirror is shown to be independent of the distance of the dipole from the mirror and equal to  $(1-\mu)$  times the decay rate in the absence of a mirror. Since reflection amplitude  $\mu$  could be equal to unity, the theoretical possibility exists that a dipole in front of a phase conjugate mirror does not radiate.

**21322.** Konowalow, D. D.; Julienne, P. S. Li, and  $\text{Na}_2^+ \Sigma_g^+ - {}^3\Sigma_u^+$  excimer emission, *J. Chem. Phys.* **72**, No. 11, 5815-5818 (June 1, 1980).

Key words: alkali dimers; excimer laser; free-bond absorption; gain cross section.

*Ab initio* calculations show the  ${}^3\Sigma_g^+ - {}^3\Sigma_u^+$  in  $\text{Li}_2$  and  $\text{Na}_2$  dimers to be primarily a near-infrared continuum with respective  $\nu' = 0$  lifetimes of 62 and 15 nsec. The peak stimulated emission cross section for  $\nu' = 0$  is  $4.5 \times 10^{-16}$  at  $1.3 \mu$  for  $\text{Li}_2$  and  $1.8 \times 10^{-15} \text{ cm}^2$  at  $0.83 \mu$  for  $\text{Na}_2$ . These calculations suggest a tunable high gain, near-infrared laser excimer if the  ${}^3\Sigma_g^+$  state can be populated sufficiently rapidly.

**21323.** Smyth, K. C.; Lias, S. G.; Ausloos, P. The ion-molecule chemistry of  $\text{C}_3\text{H}_3^+$  and the implications for soot formation, *Combust. Sci. Technol.* **28**, 147-154 (1982).

Key words: ion cyclotron resonance; ion-molecule; isomers; rate constants; reactivity; soot.

The ion-molecule chemistry of  $\text{C}_3\text{H}_3^+$  is systematically investigated with a series of alkenes, alkynes, and aromatic molecules under low-pressure, room temperature conditions. Based upon their reactivity differences, two  $\text{C}_3\text{H}_3^+$  structures are distinguished and are assigned as the cyclic (the most stable) and linear isomers. Cyclic  $\text{C}_3\text{H}_3^+$  readily reacts with unsaturated compounds having four or more carbon atoms. Linear  $\text{C}_3\text{H}_3^+$  is found to be even more reactive and, in particular, forms condensation products with acetylene and benzene. The relevance of these results for the higher temperature and atmospheric pressure conditions of a flame environment is discussed. Since  $\text{C}_3\text{H}_3^+$  has been found to be the dominant positive ion for rich and sooting hydrocarbon flames, its high reactivity provides a rapid first step in the ion models of soot formation.

**21324.** Hocken, R. J.; Haight, W. C. Multiple redundancy in the measurement of large structures, *Ann. CIRP* **27**, No. 1, 357-360 (1978).

Key words: coordinate transformation; custody transfer; energy; liquid natural gas.

The modern metrologist is increasingly being called upon to measure large structures with high accuracy. Commonly encountered are: airplane fuselage measurements, nuclear reactor component measurements, structural element measurements for prefabricated structures, and measurement of large irregularly shaped containers used in custody transfer. In this paper we will describe how the techniques of coordinate transformation and multiple redundancy, developed for small scale 3-D metrology, were used for the measurement of large Liquid Natural Gas (LNG) tanks aboard ships.

**21325.** Senich, G. A. A review of the migration of food-contact organotin stabilizers from poly(vinyl chloride), *Polymer* **23**, 1385-1387 (Aug. 1982).

Key words: diffusion; extraction; food packaging; heat stabilizers; migration; octylins; poly(vinyl chloride).

The migration of di-n-octyltin-bis(2-ethylhexyl thioglycolate) and di-n-octyltin malcate polymer, two organotin heat-stabilizers approved by the U.S. Food and Drug Administration, FDA, for poly(vinyl chloride) (PVC) used in food packaging, from PVC into foods and food simulants, is reviewed. The effects of other additives to PVC on organotin migration are considered. Methods of detecting organotins in foods and simulants are discussed. Two areas for further inquiry emerge from the review: (1) whether the intact organotin stabilizers or their degradation products migrate into simulating solvents; and (2) whether the bulk polymer or its surface is the more likely source of the stabilizer available for extraction. A bibliography of recent references is given.

**21326.** Iverson, W. P. An overview of the anaerobic corrosion of underground metallic structures, evidence for a new mechanism, *Am. Soc. Test. Mater., Spec. Tech. Publ.* **741**, 33-52 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, 1981).

Key words: anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite.

Anaerobic corrosion of iron occurs throughout the world and, from an economic standpoint, is quite costly. Sulfate-reducing bacteria, primarily of the genus *Desulfovibrio*, are responsible for this type of corrosion. It has been postulated that corrosion by these bacteria is



caused by their removal of hydrogen from the surface of iron causing it to go into solution. Evidence is presented which indicates that this mechanism may not be responsible for the main corrosive effect of these organisms. These bacteria appear to cause corrosion by producing extracellularly, under anaerobic conditions, a highly corrosive product in addition to hydrogen sulfide. The factors controlling the fate of iron in anaerobic environments, conducive to the growth of sulfate-reducing bacteria, may depend on whether iron sulfide film formation by hydrogen sulfide occurs first, thereby inhibiting corrosion, or whether the highly corrosive substance comes in contact with the iron before film formation has occurred, thereby accelerating corrosion. The antagonistic actions of these two compounds, hydrogen sulfide and the corrosive product, on corrosion produced by sulfate-reducing bacteria, could explain the conflicting observations on anaerobic corrosion noted by investigators in the field and laboratory.

- 21327.** Lieberman, A. G. **Field constraints on discontinuous solutions of the Maxwell equations**, (Proc. Optics in Four Dimensions-1980, Int. Commission for Optics, Ensenada, Mexico, Aug. 4-8, 1980), *AIP Conf. No. 65, Subseries on Optical Science and Engineering No. 1*, M. A. Machado and L. M. Narducci, eds., pp. 652-657 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1981).

**Key words:** arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; special relativity; surface charge conservation; transient propagation.

Relations governing changes in the field vectors of a discontinuous electromagnetic field are formulated in this paper within the framework of special relativity theory. The treatment emphasizes the physical aspects of the problem and for this reason the medium supporting the propagation of the discontinuity is conveniently assumed to be isotropic but otherwise to have arbitrary properties. Four field discontinuity conditions and a relation describing electrical charge conservation at the discontinuity are presented.

- 21328.** Kelley, E. F.; Hebner, R. E., Jr. **Time evolution of the electric field associated with breakdown phenomena in liquids**, (Proc. Conf. Electric Insulation and Dielectric Phenomena, Whitehaven, PA, Oct. 21-24, 1979), Paper in *1979 Annual Report: Conference on Electrical and Dielectric Phenomena*, pp. 203-211 (Office of Publications, National Academy of Sciences, 2101 Constitution Avenue, NW., Washington, DC 20418, 1979).

**Key words:** electrical breakdown; high speed photography; Kerr effect; liquid breakdown; nitrobenzene; partial discharges; streamers; transient phenomena.

This paper describes electro-optic measurements of the electric field distribution in the vicinity of prebreakdown structures in nitrobenzene. The measurements indicate that the prebreakdown structures are conducting. This conclusion was reached by modeling the structures as conducting spheres and observing that the fringe patterns calculated using the model spheres are well correlated with those photographed during breakdown.

- 21329.** LaVilla, R. E. **K absorption-edge spectrum of sodium vapor**, *Phys. Rev. A* **19**, No. 5, 1999-2001 (May 1979).

**Key words:** heat-pipe furnace; Na vapor; sodium K absorption.

Using a heat-pipe furnace as an absorption cell to contain the sodium vapor, the author measured the sodium K absorption-edge spectrum on a double-crystal monochromator. The primary features were a prominent resonance line at 1073.2 eV, a shoulder at 1074.3 eV, a weak peak at 1076.5 eV, and broad lesser features above the threshold. From an identification of the strong and weak peaks as  $1s^2 2s^2 2p^6 3s^2 S \rightarrow 1s 2s^2 2p^6 3s(^2S)np\ ^2P$  ( $n=3,4$ ), the series limit of  $1s 2s^2 2p^6 3s\ ^3S$  at  $1078.5 \pm 0.5$  eV is obtained in good agreement with the experimental value from the K-LL Auger spectrum and calculated relaxed-orbital K-electron binding energy. The lesser features above threshold are interpreted as transitions to autoionizing states in correspondence with the MgI optical spectrum.

- 21330.** LaVilla, R. E. **Unusually broad x-ray emission lines:  $L\gamma_{2,3}$**

( $L\gamma_{2,3}$ ) spectra of  $^{50}\text{Sn}$ ,  $^{52}\text{Te}$ , and  $^{53}\text{I}$ , *Phys. Rev. A* **17**, No. 3, 1018-1020 (Mar. 1978).

**Key words:** crystal spectroscopy; electrons; excitation; measurement; x-ray emission lines; x-ray photoelectron spectra.

The  $L\gamma_{2,3}$  ( $L\gamma_{2,3}$ ) x-ray emission spectra from  $^{50}\text{Sn}$ ,  $^{52}\text{Te}$ , and  $^{53}\text{I}$ , excited by direct electron bombardment, were measured with a double-crystal monochromator. The spectral profiles are similar to their 4p energy-level-region x-ray photoelectron spectra (XPS), with base widths of about 50 eV. The origin of these unusual line profiles is attributed to many-body effects in their final states which are comparable to their respective XPS final states.

- 21331.** LaVilla, R. E.; Mehlman, G.; Saloman, E. B. **Double electronic excitations in sodium above the 2s threshold**, *J. Phys. B: At. Mol. Phys.* **14**, L1-L4 (1981).

**Key words:** continuum; double electron; excitation; sodium; 2s.

The transmission spectrum in the 2s region of sodium vapour contained in a heat pipe was obtained with a 3 m monochromator using synchrotron radiation from SURF II as a source. In the continuum at photon energies greater than the 2s threshold, a number of spectral lines were observed and attributed to doubly excited transitions. A tentative classification of these lines is presented that is in close correspondence with the Mg I spectrum. Previously observed resonances, due to single-electron excitation below the 2s threshold, are confirmed. In addition, structure attributed to higher members of the single-electron excitation series was observed.

- 21332.** Lofquist, K. E. B. **Measurements of oscillatory drag on sand ripples**, *Proc. 17th Int. Coastal Engineering Conf. ASCE, Sydney, Australia, Mar. 23-28, 1980, Chapter 186*, pp. 3087-3106 (American Society of Civil Engineers, 345 East 47th Street, New York, NY 10017, 1981).

**Key words:** drag; oscillatory flow; phase dependent; ripple; sand; sea bed; stress; time dependent; unsteady; water tunnel; waves.

Measurements have been made of drag on naturally rippled sand beds in an oscillatory-flow water tunnel. A partition splits the tunnel into two parallel channels with equal cross sections and volume rates of flow, one with a smooth flat rigid bottom and the other containing the sand bed. Roughly, the difference in the two bottom drags, the one known, is equal to the difference in the net pressure forces on the water in the two channels, which is obtained from measurements of pressure differences across the partition at each end of the sand bed. Each experiment provides the drag, or average bottom stress, on the rippled sand bed as a function of the phase,  $\theta$ , of the sinusoidal flow. From a first set of thirteen experiments with a medium sand, a stress coefficient,  $f(\theta)$ , is presented in three families of curves which explore the additional effects of flow velocity, ripple length, and deviations of the ripple profile from normal equilibrium. Average rates of energy dissipation are calculated. Results show  $f$  to be a complicated function of  $\theta$  and other parameters. In particular, the instantaneous stress is not simply related to the instantaneous velocity. Some salient features of  $f(\theta)$  are described, qualitatively, by a simple model.

- 21333.** Stevens, W. J.; Krauss, M. **Ab initio effective spin-orbit operators for use in atomic and molecular structure calculations. Results for CH, OH, SiH, CO<sup>+</sup>, CO, and SiO**, *J. Chem. Phys.* **76**, No. 7, 3834-3836 (Apr. 1, 1982).

**Key words:** ab initio effective spin-orbit operators; effective potentials; spin-orbit coupling.

Ab initio effective spin-orbit operators (AESOP) for carbon and silicon are derived from relativistic effective core potentials based on Dirac-Fock atomic wavefunctions. The general transferability of these operators to electronic states other than the one used in the original derivation is treated by calculating the spin-orbit splitting of various neutral and ionic atomic states.

- 21334.** King, D. S. **Infrared multiphoton excitation and dissociation**, Paper in *Dynamics of the Excited State*, K. P. Lawley, ed., pp. 105-189 (John Wiley & Sons Ltd., New York, 1982).

**Key words:** CF<sub>2</sub>HCl; CF<sub>2</sub>CFCl; infrared excitation; multiphoton dissociation; product state distributions; review infrared multiphoton dissociation.



Critical review of advances made in 1979–1980 in field of molecular excitation in intense infrared laser fields.

21335. Levin, B.; Vreeland, R. Arsonists: Who & Why. The minds and motives of people who set fires, *Firehouse* 4, No. 8, p. 16, 51 (Aug. 1978).

Key words: arson; behavior disorder; fire; firesetters; motives; psychiatry; psychopathic personality; psychopathology.

While there is much we do not know about the psychology of a firesetter, we do have considerable relevant information. Firesetters who set fires for other than profit tend to be generally ineffective individuals with low scholastic ability or achievement. They tend to come from broken or disrupted homes and to have lived under harsh or frustrating circumstances. There does not appear to be important differences between such firesetters and other criminals and many firesetters do commit other crimes.

21336. Mann, W. B.; Unterweger, M. P.; Coursey, B. M. Comments in the NBS tritiated-water standards and their use, *Int. J. Appl. Radiat. Isot.* 33, 383-386 (1982).

Key words: tritiated water standards; tritiated water standards, half life; tritiated water standards, preparation of; tritiated water standards, use of.

A panel of consultants of the International Atomic Energy Agency has recommended the adoption of the National Bureau of Standards tritiated-water standard and the half life of 12.43 yr for use in the WMO/IAEA precipitation survey. Factors are given to convert results obtained using a previous standard and half life to the newly recommended standard and half life. The preparation of a new low-level tritiated-water standard with an activity concentration of 1.312  $\text{s}^{-1} \text{g}^{-1}$  is described.

21337. Suenram, R. D.; Thorne, L. R. Microwave spectrum and dipole moment of  $\text{BH}_3\text{NH}_3$ , *Chem. Phys. Lett.* 78, No. 1, 157-160 (Feb. 15, 1981).

Key words: borane monoammoniate; electric dipole moment; microwave spectrum; molecular structure; rotational spectrum; structure.

The microwave spectrum of two isotopic species of borane monoammoniate ( $^{11}\text{BH}_3\text{NH}_3$ ,  $^{10}\text{BH}_3\text{NH}_3$ ) have been observed using a heated microwave absorption cell. Preliminary analysis has yielded a B–N bond distance of  $r_{\text{BN}} = 1.66(3) \text{ \AA}$ . Analysis of the Stark effect of the  $J = 1 \leftarrow 0$  transition provided a dipole moment of  $5.216(17) \text{ D}$ .

21338. Stevens, W. J.; Krauss, M. Ab initio effective spin-orbit operators for use in atomic and molecular structure calculations. Results for carbon and silicon, *Chem. Phys. Lett.* 86, No. 3, 320-324 (Feb. 19, 1982).

Key words: ab initio effective spin-orbit operators; effective potentials; spin-orbit coupling.

Ab initio effective spin-orbit operators for carbon and silicon are derived from relativistic effective core potentials based on Dirac-Fock wavefunctions. Transferability of these operators to electronic states other than the one used in the original derivation is treated by calculating spin-orbit splittings of various neutral and ionic atomic states.

21339. Shapiro, S. L. Ultrafast techniques applied to DNA studies, Chapter 16 in *Biological Events Probed by Ultrafast Laser Spectroscopy*, R. R. Alfano, ed., pp. 361-383 (Academic Press Inc., 1982).

Key words: DNA; multiphoton; nanosecond; photochemistry; picosecond.

Recent experimental studies of rapid processes in DNA are reviewed. New nonlinear selectivity measurements are described in detail.

21340. Suenram, R. D.; Lovas, F. J. Dioxirane. Its synthesis, microwave spectrum, structure, and dipole moment, *J. Am. Chem. Soc.* 100, 5117-5122 (Aug. 2, 1978).

Key words: air pollution; dioxirane; dipole moment; microwave spectrum; ozone-olefin reactions; structure.

Dioxirane,  $\text{H}_2\text{COO}$ , has been identified in the reaction of ozone with ethylene at low temperature. The methods employed in synthesizing several isotopic forms of dioxirane and measurement of their rotational spectra are described. The moments of inertia obtained for  $\text{H}_2^{12}\text{C}^{16}\text{O}^{16}\text{O}$ ,  $\text{HD}^{12}\text{C}^{16}\text{O}^{16}\text{O}$ ,  $\text{H}_2^{13}\text{C}^{16}\text{O}^{16}\text{O}$ , and  $\text{H}_2^{12}\text{C}^{18}\text{O}^{16}\text{O}$  were employed in obtaining the following  $r_e$  structure:  $r_{\text{HC}} = 1.0903(18)$ ,  $r_{\text{CO}} = 1.3878(38)$ ,  $r_{\text{OO}} = 1.5155(28) \text{ \AA}$ ;  $\angle_{\text{HCH}} = 117.32(20)$ ,  $\angle_{\text{OCO}} = 66.19(18)^\circ$ . The electric dipole moment,  $\mu_e = 2.479(70) \text{ D}$ , was determined from Stark effect measurement on the  $\text{H}_2^{12}\text{C}^{16}\text{O}^{16}\text{O}$  species.

21341. Stephenson, J. C.; Bialkowski, S. E.; King, D. S. Energy partitioning in  $\text{CO}_2$  laser induced multiphoton dissociations: Energy of  $\text{CF}_2$  and  $\text{CFCl}$  from  $\text{CF}_2\text{CFCl}$ , *J. Chem. Phys.* 72, No. 2, 1161-1169 (Jan. 15, 1980).

Key words: energy transfer; intramolecular dynamics; laser-excited fluorescence; laser-induced chemistry; multiphoton processes; unimolecular reactions; vibrational relaxation.

We have measured the vibrational ( $v$ ), rotational ( $J, K$ ), and translational energy ( $E_T$ ), of the  $X \text{ CF}_2$  and  $X \text{ CFCl}$  fragments formed in the  $\text{CO}_2$  laser induced multiphoton dissociation of  $\text{CF}_2\text{CFCl}$  (chlorotrifluoroethylene):  $\text{CF}_2\text{CFCl} \rightarrow \text{CF}_2(v, J, K) + \text{CFCl}(v, J, K) + E_T(v, J, K)$ , which was the only detectable reaction path for  $\text{CF}_2\text{CFCl}$ . More vibrational energy ( $E_v$ ) appears in  $\text{CF}_2$  than in  $\text{CFCl}$ . Direct spectroscopic measurements of populations in levels  $0 < v_2 < 7$  show that  $E_v$  is distributed statistically in the bending mode ( $v_2$ ) of  $\text{CF}_2$  according to  $P(E_v) = \exp(-E_v/kT_v)$ , where  $P(E_v)$  is the probability of a  $\text{CF}_2$  product being formed with a particular amount of energy in  $v_2$ , and the vibrational temperature which characterizes the nascent distribution  $T_v(v_2) = 1860 \pm 250^\circ\text{K}$ . A vibrational relaxation method was used to accurately determine  $f_0$ , the fraction of  $\text{CF}_2$  and  $\text{CFCl}$  molecules initially formed in the ground vibrational level. The measurements of  $f_0$  showed that the energy in the stretching modes ( $v_1$  and  $v_3$ ) of  $\text{CF}_2$  is not characterized by this  $T_v(v_2)$ ; if the energy in  $v_1$  and  $v_3$  is also thermal, it must be characterized by a lower temperature:  $T_v(v_1 \text{ and } v_3) \approx 1100^\circ\text{K}$ . For the  $\text{CFCl}$  product, direct spectroscopic measurement of the relative populations in  $v_2 = 1$  and  $v_2 = 0$  are consistent with  $T_v(v_2) = 1550 \pm 300^\circ\text{K}$ . However, the measured  $f_0$  for  $\text{CFCl}$  was consistent with a thermal distribution characterized by a lower vibrational temperature. Values of  $f_0$  for  $\text{CF}_2$  were measured as a function of laser fluence for the condition where the reactant was extremely dilute ( $X_{\text{CF}_2\text{CFCl}} < 10^{-5}$ ) in a high pressure (119 Torr) of Ar buffer gas. These measurements showed that the fraction of  $\text{CF}_2$  product molecules formed in vibrationally excited states decreased from 76% to 53% as the fluence decreased by a factor of 5.5, from  $30 \text{ J cm}^{-2}$ . This decrease in  $E_v$  reflects a change in the ratio of laser excitation rate to vibrational deactivation rate for the  $\text{CF}_2\text{CFCl}$  reactant. Under conditions where collisions are unimportant, the initial rotational energy in the  $\text{CF}_2$  was probed and found to be consistent with a thermal distribution characterized by a rotational temperature  $T_R = 1550 \pm 150^\circ\text{K}$ . The translational energy  $E_T$  was the same for  $\text{CF}_2$  fragments formed with no vibrational energy and for those formed in the  $v_2 = 5$  level with  $E_v = 3320 \text{ cm}^{-1}$ , and  $E_T$  was also the same for products formed with little rotational excitation ( $E_R \approx 40 \text{ cm}^{-1}$ ) and for those born with substantially higher rotational energy ( $E_R = 240 \text{ cm}^{-1}$ ). The kinetic energy of the products is less than that observed in the photodissociation of  $\text{CF}_2\text{HCl}$ .

21342. King, D. S.; Stephenson, J. C. Laser intensity effects in the IR multiphoton decomposition of  $\text{CF}_2\text{HCl}$ , *Chem. Phys. Lett.* 66, No. 1, 33-38 (Sept. 15, 1979).

Key words:  $\text{CF}_2\text{HCl}$  (chlorodifluoromethane); induction times; infrared laser; intensity dependence in infrared photochemistry; laser chemistry; laser excited fluorescence; multiphoton dissociation; unimolecular dissociation rates.

Major intensity effects were observed in the collision-free  $\text{CO}_2$  laser-induced dissociation of  $\text{CF}_2\text{HCl}$  utilizing real-time laser-excited fluorescence diagnostics. At constant fluence: increasing average pulse intensities by 6 increased dissociation yields 400 fold; pulse mode-locking caused 5–10 fold increases in yield. Induction times reflect threshold behavior. Collisions reduce laser intensity effects.



**21343.** Miller, J. H.; Mallard, W. G.; Smyth, K. C. The observation of laser-induced visible fluorescence in sooting diffusion flames, *Combust. Flame* **47**, 205-214 (1982).

Key words: diffusion flames; flame stabilization; laser-induced fluorescence; polycyclic aromatic hydrocarbons; recirculation; soot formation.

Visible fluorescence is produced using an argon-ion laser for excitation in sooting methane/air and methane/oxygen diffusion flames. This emission is attributed to small (two to four ring) polycyclic aromatic hydrocarbons, as suggested by previous studies. The key finding in the present investigation is that the fluorescence spectra can be altered dramatically by changes in the flame stabilization conditions. Spectra obtained with a slot burner and a cylindrically symmetric burner are presented, and are usually found to be broad and unstructured. However, under certain experimental conditions the laser-induced fluorescence spectra show considerable structure; four distinct peaks are identified at different excitation wavelengths. Evidence is presented that the structured spectra are caused by recirculation of downstream combustion gases (and particles) into the optically sampled area. Thus, these observations point out the importance of characterizing the flow conditions when optical measurements are used to study the flame chemistry of polycyclic aromatic molecules. Possible temperature effects and the relevance of the results to soot formation processes are also discussed.

**21344.** Mordfin, L. Standards for residual stress measurement, (Proc. Residual Stress Effects in Fatigue, Phoenix, AZ, May 11, 1981), *Am. Soc. Test. Mater., Spec. Tech. Publ.* **776**, 6-12 (1982).

Key words: fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; residual stress; standards; stress measurement; terminology; ultrasonics; x-ray diffraction.

It has been long appreciated that residual stresses can exert significant influences on fatigue and fracture behavior, but only recently have analytical models been developed which enable the influences to be quantified. These new capabilities have fostered increased demands for residual stress measurements and these, in turn, have revealed that the reliability and the reproducibility of such measurements are often less than adequate. The need for standards for residual stress measurements is now recognized as being urgent. Few standards presently exist, and they do not provide the required levels of measurement reproducibility.

Several organizations are attempting to respond to this critical need. This paper is a status report on the growing national effort to develop voluntary consensus standards to enhance the reproducibility of residual stress measurements. This effort has achieved noteworthy progress in only a few years, but it has also become evident that further progress will be increasingly more difficult because our understanding of some residual stress phenomena is limited. There is need for a national research effort to parallel and to support the standardization effort.

**21345.** O'Connell, J. S. Photonuclear reactions above the pion threshold, *Proc. Int. School of Intermediate Energy Nuclear Physics, Verona, Italy, July 16-26, 1981*, pp. 189-215 (World Scientific Publ. Co. Pte Ltd., P.O. Box 128, Farrer Road, Singapore 9128, 1982).

Key words: electron; Fermi gas model; Feynman diagrams; meson exchange current; nucleus; photon; pion.

Nuclear reactions initiated by photons on electrons that excite the nucleus more than 140 MeV are reviewed with the aim of describing the nucleon and meson currents inside the nucleus.

**21346.** Shaub, W. M. Procedure for estimating the heats of formation of aromatic compounds: Chlorinated benzenes, phenols and dioxins, *Thermochim. Acta* **55**, 59-73 (1982).

Key words: chlorinated benzenes; chlorinated dioxins; chlorinated phenols; estimation; heats of formation; procedure.

A method for estimating the gas phase heats of formation of some aromatic organic compounds is applied. A critical comparison of the gas phase heats of formation predicted by this method with the gas phase heats of formation reported experimentally for several aromatic

organic compounds is presented. Practical applications of this method are illustrated for chlorinated dioxins, chlorinated phenols and chlorinated or fluorinated benzene molecules. The limitations and practical extensions of the method are discussed. The method is shown to be simple and of practical usefulness, particularly when required experimental data are unavailable.

**21347.** Mies, F. H. Quantum theory of atomic collisions in intense laser fields, *Theoret. Chem.: Adv. Perspectives* **6B**, 127-198 (1980).

Key words: atomic collisions; close-coupled scattering theory; dressed-atoms; inelastic cross-sections; laser; laser-induced collisions; radiation theory; stimulated emission.

Quantum theory of laser-induced inelastic atomic collisions is developed. Multiphoton transitions and the properties of the laser-field are carefully analyzed and the close-coupled equations for the scattering are derived. Both stimulated and spontaneous emission is treated in the weak-field limit, and the nonlinear behavior of the cross-sections in strong-fields is discussed. Particular care is given to the conservation laws that can be expected in the presence of radiation.

**21348.** Shapiro, S. L.; Cavanagh, R. R.; Stephenson, J. C. Streak-camera observations of the pulse emission from a synchronously pumped continuous-wave mode-locked dye laser, *Opt. Lett.* **6**, No. 10, 470-472 (Oct. 1981).

Key words: dye laser; mode-locked; picosecond; pulse emission; streak-camera; tunable.

Pulse emission from a synchronously pumped cw mode-locked dye laser is investigated with a streak camera. Prominent satellite pulses with nonrepetitive temporal spacing can be detected that are difficult to observe with an autocorrelator.

**21349.** Reed, K. A. Instrumentation for thermal performance measurements: Striving for measurement assurance in solar collector testing, *Proc. Fourth Annu. Conf. ASME Solar Energy Division, Albuquerque, NM, Apr. 26-29, 1982*, pp. 337-340 (The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017, Apr. 1982).

Key words: fluid flow; instrumentation; irradiance; measurements; solar; temperature.

This paper reviews the instrumentation commonly used to measure the primary physical variables needed to determine the thermal performance of active solar energy equipment, especially liquid-type solar collectors. These variables include fluid flow, temperature difference, and irradiance. Measurement techniques and difficulties are discussed, as are typical measurement uncertainties.

**21350.** Bechtoldt, C. J.; Placious, R. C.; Boettinger, W. J.; Kuriyama, M. X-ray residual stress mapping in industrial materials by energy dispersive diffractometry, *Adv. X-Ray Anal.* **25**, 329-338 (1982).

Key words: energy dispersive diffractometry; high energy photons; residual stress.

An application of energy dispersive diffractometry to the measurement of residual strains (stresses) in the interior of industrial materials is described with particular emphasis on the use of high energy (up to 250 keV) x-ray photons. The use of high energy photons permits better penetration into materials. Hence diffraction data for evaluating bulk residual strains can be obtained in the transmission geometry in contrast with the conventional angular dispersive diffractometry, which uses Bragg reflections from the surface of materials. The reliability and sensitivity (detectability of small strains) of the energy dispersive method are demonstrated through its application to mapping of residual stress distributions across weld zones in Alaskan pipe line segments (API5LX65). The detectability of strain variations within materials depends on x-ray optical resolution and statistics.

The energy dispersive system is simple and compact, and involves no moving parts. Through the present demonstration, this energy dispersive method shows great promise for providing a powerful nondestructive tool for the evaluation or mapping of residual stress distributions within bulk materials. This method is particularly suitable for inspection and monitoring of industrial materials.



21351. Soulen, R. J., Jr.; Van Vechten, D.; Costabile, G.; Jach, T.; Holdeman, L. B. The superconductive energy gap of  $\text{AuAl}_2$ , *Physica* 108B, 823-824 (1981).

Key words:  $\text{AuAl}_2$ ; energy gap; superconductivity; tunneling.

We have prepared 200 nm films of  $\text{AuAl}_2$ . The superconductive transition determined by resistive measurements was found to vary from film to film, from 177 to 184 mK, and the transition widths varied between 6 and 15 mK. Film surfaces were oxidized by the Greiner process and Al counter electrodes were deposited in order to produce tunnel junctions. The temperature dependence of the energy gap of  $\text{AuAl}_2$  was measured and found to agree well with BCS theory.

21352. Hebner, R. E.; Kelley, E. F.; Forster, E. O.; Fitzpatrick, G. J. Observation of prebreakdown and breakdown phenomena in liquid hydrocarbons, *J. Electrostat.* 12, 265-283 (1982).

Key words: breakdown; dielectrics; high voltage; insulation; liquids; shock waves.

Prebreakdown and breakdown events under quasiuniform fields in n-hexane, isooctane, cyclohexane and toluene have been photographed. For each liquid, two types of breakdown pattern are observed. One pattern is characteristic of growth from the cathode while the other is characteristic of growth from the anode. The measured postbreakdown phenomena were identical in all cases.

In addition to the optical studies, microscopic observations showed that organic films were produced on the electrode surface and that lead accumulates preferentially in the area of the electrode surface where breakdown occurs.

21353. Yoo, K. C.; Roessler, B.; Armstrong, R. W.; Kuriyama, M. Reflection x-ray topography of hardness indentations in copper single crystals, *Scr. Metall.* 15, 1245-1250 (1981).

Key words: copper single crystal; image contrast; indentation hardening; plastic deformation; x-ray topography.

The plastic deformation zones surrounding microhardness indentations put into the (110) surfaces of relatively soft copper and nickel single crystals have been studied by the asymmetrical crystal topography (ACT) method. The method gives valuable information about the importance of workhardening to determining the level of the microhardness pressure and to determining the magnitude of its anisotropy for different directions of the indenter axes for Knoop or diamond pyramid indentations. This is demonstrated especially for copper crystals by the very pronounced appearance of the strain patterns of diffraction contrast obtained at either type of hardness impression. Both the cumulative dislocation displacements (for extinction contrast) and their lattice rotations (for misorientation contrast) are employed in the analysis of the topographic strain patterns.

21354. Knab, L. I.; Jenkins, D. R.; Mathey, R. G. The effect of moisture on the thermal conductance of roofing systems, *Proc. ASHRAE/DoE Conf. Thermal Performance of the Exterior Envelopes of Buildings, Kissimmee, FL, Dec. 3-5, 1979*, pp. 816-835 (ASHRAE, 345 East 47th Street, New York, NY 10017, 1981).

Key words: built-up roofing; insulation; moisture; roofing; thermal conductance; thermal conductivity; thermal resistance.

The results of laboratory tests are presented describing the effect of moisture content on the thermal conductance of roofing systems containing insulation. Roofing systems, consisting of five types of rigid-board roof insulations with attached four-ply bituminous built-up membrane, were tested. Moisture was induced into the roofing system specimens by maintaining a constant water vapor pressure difference across them. Moisture gain in the insulation varied depending on the type and thickness of the insulation.

A procedure was developed, using a heat-flow meter apparatus (ASTM C 518 type), to carry out thermal conductance tests on roofing specimens containing moisture. More than 200 tests were performed over a wide range of moisture contents. The approximate moisture distribution in the insulation was determined from core samples.

Relationships between the thermal conductance and moisture content are presented. The relationships show that the presence of

moisture in roofing systems can cause significant increases in thermal conductance, depending on the type and thickness of the insulation.

21355. Mann, W. B. The radioactivity standards programme of the National Bureau of Standards, *Proc. IAEA Symp., Natl. and Int. Standardization of Radiation Dosimetry, Atlanta, GA, Dec. 1977*, II, 147-154 (International Atomic Energy Agency, Vienna, 1978).

Key words: absorbed dose; environment; radioactivity; radiopharmaceuticals; standards; traceability.

From nuclear data tables, such as those compiled by the Oak Ridge Nuclear Data Project, the absorbed dose to a homogeneous medium can be calculated from given values of the mean energy per decay, expressed in gram rad per microcurie hour. To make any of these calculations the activities of the various components of radioactive effluents or of the administered radiopharmaceuticals must be known. For more than ten years the Radioactivity Section of the National Bureau of Standards has been devoting a very considerable part of its effort to the production of radioactivity standards that are needed in environmental and nuclear-medicine measurements. Such standards are also being produced in appropriate environmental matrices and the latest available nuclear-decay data, often produced in the Radioactivity Section, is also supplied. Traceability to the International and National Radioactivity Measurements Systems is discussed.

21356. Reader, J.  $2s^22p^5-2s2p^6$  transitions in the fluorinelike ions  $\text{Sr}^{29+}$  and  $\text{Y}^{30+}$ , *Phys. Rev. A* 26, No. 1, 501-503 (July 1982).

Key words: ion; laser-produced plasma; spectrum; strontium; vacuum ultraviolet; yttrium.

The  $2s^22p^5-2s2p^6$  transitions in  $\text{Sr}^{29+}$  and  $\text{Y}^{30+}$  have been observed by means of a laser-produced plasma and a 2.2-m grazing-incidence spectrograph. Comparison of the observed  $2s^22p^5 \ ^2P_{3/2-1/2}$  fine-structure intervals with values calculated by the Dirac-Fock method allows accurate wavelengths to be predicted for the  $2s^22p^5 \ ^2P_{3/2-1/2}$  magnetic-dipole transitions in the isoelectronic series of ions  $\text{Kr}^{27+}$ ,  $\text{Mo}^{33+}$ .

21357. Madden, R. P.; Parr, A. G. Resonance phenomena in molecular photoionization: Impact of synchrotron radiation, *Appl. Opt.* 21, No. 2, 179-188 (Jan. 15, 1982).

Key words: autoionization; photoelectron spectroscopy; shape resonance; synchrotron radiation.

The nature of resonance phenomena in atomic and molecular systems is reviewed along with a discussion of the utilization of synchrotron radiation in studying resonance phenomena. The effects of autoionization and shape resonances on the branching ratios and asymmetry parameters for several systems are discussed. The potential and current status of threshold photoelectron spectroscopy and ion coincidence techniques are discussed.

21358. Early, J. Recycling (ferrous metals), *Encyclopedia. Chem. Technol.* 19, Third Edition, 952-962 (John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158, 1982).

Key words: ferrous scrap; iron; municipal solid waste; recycling; resource recovery; standards; steel.

The secondary metals industry associated with the recycling of ferrous scrap is tied to the development in the 1850's of the acid-Bessemer furnace, the first large capacity steelmaking process. Within twenty-five years of this development, the recycling of ferrous scrap became an established industry. Changes in steelmaking technology since World War II, especially since the 1960's, are impacting the traditional ferrous scrap industry. The demand for the increased recovery of old scrap has increased partly due to substantial growth in electric-arc furnace steelmaking capacity and partly due to reduced availability of home scrap and prompt industrial scrap. Ferrous scrap recovered from municipal solid waste is one of the new sources of old scrap that may satisfy these increased demands. Processes and systems for the recovery of the ferrous fraction from municipal solid waste have been developed and a number of these facilities are presently producing about 200,000 tons of municipal ferrous scrap per year. Growth of this source of ferrous scrap, however, has been very slow due to both institutional and technical barriers. Although real, even in



the absence of institutional obstacles, the technical barriers, primarily physical and chemical characteristics of this ferrous material, would strongly inhibit the development of markets for this new material. The real and potential markets for increased consumption of municipal ferrous scrap are discussed in terms of these barriers and the approaches available to decrease their influence. Finally, the important role of standards for municipal ferrous scrap in improving communications between buyers and sellers of this material is discussed.

- 21359.** Mordfin, L. Advanced diffraction techniques for the nondestructive evaluation of internal residual stresses, *Proc. Seventh Int. Conf. Experimental Stress Analysis, Haifa, Israel, Aug. 23-27, 1982*, pp. 602-603 (The Technion, Israel Institute of Technology, Haifa, Israel, 1982).

**Key words:** diffraction; high-energy x-rays; internal stress; neutron diffraction; nondestructive evaluation; residual stress; stress analysis; x-ray diffraction.

Advanced techniques for the evaluation of stresses and strains in the interior of solid bodies are being developed at the U.S. National Bureau of Standards (NBS). These techniques, which are based upon Bragg diffraction, use thermal neutrons and high-energy x-rays to achieve depths of penetration not attainable by conventional x-ray diffraction techniques.

- 21360.** Unguris, J.; Pierce, D. T.; Galejs, A.; Celotta, R. J. Spin and energy analyzed secondary electron emission from a ferromagnet, *Phys. Rev. Lett.* **49**, No. 1, 72-76 (July 5, 1982).

**Key words:** electron spin polarization; ferromagnetic glass; scanning electron microscopy; secondary electron emission; spin analyzer; spin polarized secondary electron.

Measurements are presented of the energy dependence of the spin polarization of low-energy (0.5-25 eV) secondary electrons when a 500-eV primary beam is incident on an iron-based ferromagnetic glass. The polarization of the lowest-energy electrons is found to correspond to the net valence-band spin density. Possible causes for the observed decrease in polarization with increasing secondary energy are discussed. The results demonstrate a mechanism for measuring surface magnetic structure with the very high spatial resolution of scanning electron microscopy.

- 21361.** Yap, W. T.; Doane, L. M. Determination of diffusion coefficients by chronoamperometry with unshielded planar stationary electrodes, *Anal. Chem.* **54**, No. 8, 1437-1439 (July 1982).

**Key words:** chronoamperometry; coefficient; diffusion; electrodes; examination; planar; stationary; unshielded.

Several methods of determining the diffusion coefficient from chronoamperometric data of unshielded planar stationary electrodes are examined. It is concluded that none of the methods completely account for the deviation of  $it^{1/2}$  vs.  $t^{1/2}$  curves and that all the methods employed are accurate within 5 percent.

- 21362.** Parker, R. L. Ultrasonic measurement of solid/liquid interface position during solidification and melting of metals, (Proc. Physics in the Steel Industry, Lehigh University, Bethlehem, PA, Oct. 5-7, 1981), *AIP Conf. No. 84*, 254-271 (American Institute of Physics, New York, NY, June 1982).

**Key words:** interface; measurement; melting; metals; process control; pulse-echo technique; signal processing; solidification; ultrasonics.

The use of pulse-echo ultrasonic flaw detectors to detect the presence and location of cracks, voids, and other discontinuities in metals and non-metals is well known. The solid-liquid interface in a melting or freezing metal can also be considered as a discontinuity, in that there is a measurable difference in both sound velocity and density across the interface. For normal incidence of longitudinal waves in a typical case, about 10% of the pressure amplitude of the incident wave would be expected to be reflected. Thus such a technique, if it worked, could be considered as a method for measurement, feedback, and closed-loop process control in such applications as continuous casting of metals.

To examine the feasibility of this technique, the melting and

freezing of 99.9 Sn has been studied at NBS using pulse-echo equipment at a nominal frequency of 5 MHz. The transducer contacts the cold end of a 5/16" x 8" specimen in a graphite mold in a Bridgman gradient furnace (unidirectional melting/solidification). Sharp echoes easily locate the interface position, in both freezing and melting, to  $\pm 1$  mm, over the range of interface velocities tested (up to  $\sim 4$  mm/min).

A literature search showed that similar or related tests have been made by at least 5 other groups in the U.S. and abroad, in a number of materials and geometries. Most of them were also successful in locating the interface. In the relatively difficult case of steel, while interfaces could be located under certain conditions, there were also found some substantial problems involving signal attenuation and poor signal/noise ratios. Some possible causes for this could be poor reflection of the incident beam from the dendritic "mushy zone" in the case of alloys, as well as bulk attenuation effects due to grain size or other scattering centers. In the case of continuous castings, the coupling of the acoustic energy into hot, rough and scaly surfaces presents additional problems. However, much progress has been made in recent years on the problems of getting acoustic energy into hot steel surfaces, including the use of non-contact Lorentz-force transducers (EMATs).

NBS work is focussed on the study of the measurement factors inherent in possible use of the method for process control, as well as possible use for interface characterization. In those cases, such as steel continuous casting, where signal/noise problems may be limiting, appropriate signal processing techniques should make it possible to improve signal/noise ratios. These techniques include corrections for transducer response as well as signal averaging and correlation techniques. To do this, a sampling oscilloscope is used to provide a slowed but shape-preserving output of the received echo, which is then fed to a digitizer and then to a small computer (64K memory, Z-80 CPU, 8" floppy discs).

- 21363.** Blanc, R. P.; Heafner, J. F. Off-the-shelf solutions motivate NBS's standards drive, *Data Commun.*, 4 pages (McGraw-Hill Inc., Mar. 1982).

**Key words:** computer networks; Federal Information Processing Standards; International Organization for Standardization; local area networks; National Bureau of Standards; network protocols; standards.

Many organizations in the United States as well as in other countries are faced with problems of achieving organizational network systems compatibility. This compatibility can be achieved through an agreed upon set of network protocol standards. Such a set of standards would have the greatest possible impact if the agreements were as widespread as possible, preferably internationally. Such an international agreement on network protocol standards would have the greatest potential for leading to off-the-shelf implementations of these protocols. This paper summarizes the national and international efforts to standardize a set of network protocols to permit systems integration on a network-wide basis. The paper describes the program of the National Bureau of Standards (NBS) in computer network protocols standardization in the context of these national and international efforts. The specifications which NBS will be proposing as Federal Information Processing Standards (FIPS) are based on the work of the International Organization for Standardization (ISO) and the requirements of the Federal Government.

- 21364.** Kingston, H.; Pella, P. A. Preconcentration of trace metals in environmental and biological samples by cation exchange resin filters for x-ray spectrometry, *Anal. Chem.* **53**, No. 2, 223-227 (Feb. 1981).

**Key words:** cation exchange resin-loaded filters; environmental samples; ultratrace analysis; x-ray spectrometry.

A preconcentration method is described for the X-ray spectrometric analysis of several trace elements in seawater, NBS-SRM 1648 urban particulate, NBS-SRM 1632 trace elements in coal, and nickel in urine at concentrations as low as 1 ppb. The elements in the coal and urban particulate samples were loaded quantitatively on cation exchange resin filters and subsequently analyzed by energy-dispersive X-ray fluorescence spectrometry using secondary targets for monochromatic excitation of the filter sample. Prior to the analysis of seawater and urine the trace elements from the matrix were separated with a chelating resin. Comparison of the results



obtained with NBS-SRM certificate values and/or those of other workers indicated agreement within  $\pm 10\%$ . Detection and quantitation limits for this preconcentration method are also presented.

- 21365.** Wiese, W. L.; Konjevic, N. Regularities and similarities in plasma broadened spectral line widths (Stark widths), *J. Quant. Spectrosc. Radiat. Transfer* 28, No. 3, 185-198 (1982).

Key words: isolated lines; neutral and ionic spectra; regularities; similarities; Stark broadening.

Regularities and similarities in plasma broadened line widths have been studied by a comprehensive analysis of existing experimental data. Regularities are expected on the basis of general atomic structure considerations, and should be evident for spectral series, for corresponding transitions in homologous atoms and in isoelectronic sequences. Furthermore, similarities of line widths are expected for multiplets, supermultiplets and, to a lesser degree, for transition arrays. A comprehensive examination of literature data has been undertaken, which shows generally a close adherence of the measured data to the expected regularities. A few notable exceptions are also given.

- 21366.** Yin, L. I.; Trombka, J. I.; Schmadebeck, R. L.; Seltzer, S. M.; Bielefeld, M. J. A hard x ray and soft gamma ray telescope spectrometer, *SPIE* 268, 97-102 (1981).

Key words: digitizing anode; gamma ray; microchannel plate; multiple-pinhole mask; spectrometer; telescope; x ray.

We propose a new design of a hard X-ray and soft gamma-ray telescope spectrometer in the energy domain of 30 keV to 200 keV with reasonable spatial, temporal, and energy resolution for possible space flight missions. This design incorporates a Uniformly Redundant Array (URA) mask in the front end and the Low Intensity X-ray Imaging Scope (Lixiscope) developed in our laboratory as the imaging spectrometer. Using a newly acquired intensifier tube with a digitizing anode, preliminary results indicate that such a complete hard X-ray and soft gamma-ray telescope spectrometer system is indeed feasible.

- 21367.** Younger, S. M. Electron-impact-ionization cross sections for highly ionized chlorinelike ions, *Phys. Rev. A* 25, No. 6, 3396-3398 (June 1982).

Key words: chlorine-like ions; distorted wave theory; electron ionization.

Electron-impact-ionization cross sections have been computed for Ar II, K III, Sc V, and Fe X in a distorted-wave Born exchange approximation. For Ar II, the theoretical results are in good agreement with available experimental data. An analytic fit to the data is provided.

- 21368.** Green, R. L. A relaxation theory of Stark broadening by ions, *J. Quant. Spectrosc. Radiat. Transfer* 27, No. 6, 639-651 (1982).

Key words: Balmer lines; ion dynamics; Lyman series; plasma broadening; plasma theory; relaxation theory; Stark broadening.

A theory of Stark broadening in plasmas is presented in which the effects of broadening by ion perturbers are treated in a manner similar to the relaxation theory or unified theory for electrons. An expression is derived for Fano's broadening operator  $M(\omega)$  which does not contain the projection operators or cumulants of previous forms. To obtain a calculable expression for  $M(\omega)$ , an approximation is made in which small, second-order fluctuation terms are replaced by their adiabatic limits. Sample calculations are presented for the first two members of the Lyman and Balmer series of hydrogen which show reasonable agreement with experiment, although the "dip" of the  $\beta$ -lines is still too pronounced.

- 21369.** Cezairliyan, A.; Müller, A. P.; Righini, F.; Rosso, A. Radiance temperature of metals at their melting points as possible high temperature secondary reference points, (Proc. Sixth Symp. Temperature, National Bureau of Standards, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., 5, 377-381 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: high temperature; radiance temperature at melting point; reference points; refractory elements.

A summary is given of the measurements performed at the National Bureau of Standards and at the Istituto di Metrologia for the determination of the radiance temperature at two wavelengths (near 0.65 and 1  $\mu\text{m}$ ) of selected metals (Fe, Pd, Ti, Zr, V, Nb, Mo, and Ta) at their melting points. The melting temperature of the metals studied ranged from about 1800 to 3300 K. All the experiments were performed with a pulse-heating technique, in which the specimen was heated from room temperature to its melting point in less than one second by the passage of an electrical current pulse through it. Millisecond-resolution optical pyrometry was used for temperature measurements. The measurements show constancy and reproducibility of the radiance temperature at the melting point for a given metal, irrespective of the initial surface conditions of the specimen, and of operational conditions. The results suggest the possibility of the use of the radiance temperature of selected metals at their melting point as secondary reference points.

- 21370.** Spence, D.; Chupka, W. A.; Stevens, C. M. Search for long-lived doubly charged atomic negative ions, *Phys. Rev. A* 26, No. 1, 654-657 (July 1982).

Key words: atomic negative ions; doubly charged ions; mass spectrometry; Penning ion source.

Using the Argonne 100-in.-radius double-focusing mass spectrometer we have searched for long-lived ( $>10^{-5}$  sec) doubly charged atomic negative ions with the use of electron impact and Penning ionization sources. Our source operating conditions are similar to those of previous experiments which claim the existence of such ions. In contrast to all previous experiments, our mass resolution is sufficient to absolutely identify any impurity ion from its mass defect, and the machine design is such that artifact peaks (Aston peaks), caused by collisional dissociation of molecular negative ions, do not occur. Using a variety of target gases, we set upper limits for the production of doubly charged or singly charged species in electron bombardment and Penning sources of  $X^{2-}$  to  $X^{-} < 10^{-7}$  to  $10^{-8}$  and  $X^{2-}$  to  $X^{-} < 5 \times 10^{-10}$ , respectively. These results contrast to those of previous experiments which claim positively identified ratios of  $X^{2-}$  to  $X^{-} = 10^{-1}$  to  $10^{-2}$  and  $X^{2-}$  to  $X^{-} \approx 10^{-3}$ , respectively. We find no evidence of any doubly charged atomic negative ion.

- 21371.** Wong, J. S.; Moore, C. B. Inequivalent C-H oscillators of gaseous alkanes and alkenes in laser photoacoustic overtone spectroscopy, *J. Chem. Phys.* 77, No. 2, 603-615 (July 15, 1982).

Key words: alkanes; alkenes; C-H vibrations; laser photoacoustic spectroscopy.

The overtone spectra of the C-H stretching vibrations of several gaseous alkanes and alkenes were observed using laser photoacoustic spectroscopy. Resolvable peaks are seen for each chemically or sterically equivalent C-H bond and are assigned using the local mode model. The fifth overtone transition energies decrease linearly with increasing C-H bond lengths. Spectral shifts corresponding to 0.001 Å bond length differences are observed. Linear correlations of bond length and anharmonicity with fundamental C-H stretching frequency allow a Morse potential for CH bonds to be defined in terms of a single parameter. The integrated cross section per C-H oscillator for the fifth overtone spectra varied mostly within a factor of 2 about the average value of  $(1.08 \pm 0.28) \times 10^{-23} \text{ cm}^2 \text{ cm}^{-1}$ .

- 21372.** Moody, J. R. Some considerations of analytical chemical methodology relevant to testing of leachates from radioactive solids, *Nucl. Chem. Waste Manage.* 3, 29-33 (1982).

Key words: chemical blank; contamination control; leachates; leach testing; nuclear waste; trace elements. nuclear waste; trace elements.

The analysis of leachate derived from simulated radioactive solids provides an interesting challenge from both an instrumental and a chemical point of view. Because of the low anticipated leach rates, the elemental concentrations of interest are also low. Consequently, contamination or analytical blank problems are significant. Both the analyte (analyzed leachate) and the blank measurements have a



statistical precision and therefore the difference between the two should have a calculable precision. Measurement accuracy, however, is not related to this calculated value. Without either knowing the absolute values in advance or having a sufficiently well characterized Standard Reference Material (SRM) it will not be possible to establish the absolute accuracy. Instrumental methods may produce a bias and extensive round robin tests alone do not establish the magnitude of these biases unless a suitable control or SRM material is used simultaneously. The largest anticipated chemical problem associated with trace and ultratrace element determinations in leach tests is that of sample contamination. Methods have been developed at the National Bureau of Standards (NBS) and other laboratories which can reduce or control contamination, however, it is important to realize that there are practical limits and contamination, per se, cannot be totally eliminated.

21373. Moody, J. R. Sample handling for trace element analysis, (Proc. Analytical Division Symp. Trace Analysis, Royal Society of Chemistry, University College, Cardiff, Wales, UK, Sept. 23-26, 1980), Paper in *Anal. Proc. (London)* 18, No. 8, 337-339 (Royal Society of Chemistry, London, UK, Aug. 1981).

Key words: analytical blank; contamination control; sample handling; sample storage; sampling; trace element analysis.

In recent years, new instrumental advances have pushed instrumental detection limits to lower levels. At the same time, many matters of public concern have demanded more than conventional methodology was capable of handling from matrices as diverse as seawater, freshwater, botanical and biological samples, oils, coals, fly ash and various waste materials. Only rarely is an analyst able to take a real world sample and proceed to the measurement step without some sample processing chemistry. Unfortunately, in the real world, it is usually the magnitude of the analytical blank which determines the practical lower limit of elemental analysis. The size of the blank, in a large measure, will be a function of the types of sample processing involved and the corresponding contamination for each step. By rigorous attention to detail it is often possible to provide a very significant reduction in the analytical blank, thus lowering the working analytical range for nearly all analytical techniques.

21374. Janghorbani, M.; Young, V. R.; Gramlich, J. W.; Machlan, L. A. Comparative measurements of zinc-70 enrichment in human plasma samples with neutron activation and mass spectrometry, *Clin. Chim. Acta* 114, 163-171 (1981).

Key words: dietary enrichment; isotopes; mass spectrometry; neutron activation; plasma; zinc.

Radiochemical neutron activation analysis (RNAA) is compared with isotope ratio mass spectrometry (IRMS) for the measurement of  $^{70}\text{Zn}$  isotopic enrichment in human plasma following oral administration of the isotope. It is shown that both techniques are suitable for this purpose, although IRMS yields more precise data. Each method, with its advantages and limitations, can be realistically employed to study kinetics of appearance of  $^{70}\text{Zn}$  in plasma obtained during human metabolic studies.

21375. Elliott, D. S.; Rajarshi, R.; Smith, S. J. Extracavity laser bandshape and bandwidth modification, *Phys. Rev. A* 26, No. 1, 12-18 (July 1982).

Key words: acousto-optic; bandshape; bandwidth; broadening; laser; modulation; noise.

A technique for modifying the laser power spectrum by use of an acousto-optic modulator is described. The theory of the power spectrum resulting from frequency modulation by Gaussian noise is reviewed, and several examples of broadened laser power spectra are presented.

21376. Janev, R. K.; Joachain, C. J.; Nedeljkovic, N. N. Molecular-energy splitting of highly excited states in the two-Coulomb-center problem, *Phys. Rev. A* 26, No. 1, 116-124 (July 1982).

Key words: highly excited states of  $E(Z_1eZ_2)$  system; molecular energy splitting; two-Coulomb-center problem.

With the use of the comparison-equation method, asymptotically exact analytical expressions are derived for the molecular-energy

splittings of highly excited states of the one-electron two-Coulomb-center system ( $Z_1eZ_2$ ). Both the symmetrical ( $Z_1=Z_2$ ) and nonsymmetrical ( $Z_1\neq Z_2$ ) cases are studied. The physical implications of our results are discussed, and their relationship with the expressions corresponding to low-lying states is analyzed.

21377. November, L. J.; Toomre, J.; Gebbie, K. B.; Simon, G. W. Vertical flows of supergranular and mesogranular scale observed on the Sun with *OSO 8*, *Astrophys. J.* 258, No. 2, 846-859 (July 15, 1982).

Key words: atmospheric motions; chromosphere; Sun; supergranulation.

Steady flows have been observed at disk center on the quiet Sun using the University of Colorado Ultraviolet Spectrometer on *OSO 8* and the diode-array instrument at Sacramento Peak Observatory. Simultaneous observation in Fe I  $\lambda 5576$ , Mg I  $\lambda 5173$ , and Si II  $\lambda 1817$  allow us to compare time-averaged Doppler velocities over a height range of 1400 km from the photosphere to the middle chromosphere. It is shown that patterns of steady vertical velocity with the largest spatial scales of supergranulation are present in the middle chromosphere, where they correlate well with those seen lower in the atmosphere. Such patterns are seen to persist for at least 9 hr, with downflow generally occurring in regions of enhanced intensity, and upflow in the darker areas. Observed with  $10'' \times 20''$  spatial resolution, the spatial rms velocity amplitudes increase from about  $30 \text{ ms}^{-1}$  in Fe I and Mg I to about  $350 \text{ ms}^{-1}$  in Si II. Higher spatial resolution reveals that variations on smaller horizontal scales of about  $10''$  are also present in the Si II velocity data, although these do not correlate directly with the mesogranulation seen in Fe I and Mg I. With  $2'' \times 20''$  resolution, the spatial rms of the time-averaged velocity is about  $700 \text{ ms}^{-1}$ , compared with about  $40 \text{ ms}^{-1}$  in Fe I and  $50 \text{ ms}^{-1}$  in Mg I.

21378. Simpson, J.; Hocken, R.; Albus, J. The automated manufacturing research facility of the National Bureau of Standards, *J. Manuf. Syst.* 1, No. 1, 17-31 (1982).

Key words: automated machining; hierarchical control; manufacturing research; research facility.

A major facility for manufacturing research is being established at the National Bureau of Standards (NBS). The facility is designed to provide extreme flexibility to be capable of emulating a wide variety of manufacturing cells typical of a small machine job shop. The control architecture adopted is hierarchical in nature and highly modular. The facility will be used for research on interface standards and metrology in an automated environment.

21379. Van Brunt, R. J. Effects of  $\text{H}_2\text{O}$  on the behavior of  $\text{SF}_6$  corona, *Proc. Seventh Int. Conf. Gas Discharges and Their Applications, Imperial College of Science and Technology, London, UK, Aug. 31-Sept. 3, 1982*, pp. 255-258 (Peter Peregrinus Ltd., London, UK, 1982).

Key words: corona discharges; electron avalanches; gas chromatograph; mass spectrometer;  $\text{SF}_6$ ; streamer pulses; sulfurhexafluoride; water vapor.

The effects of trace amounts of  $\text{H}_2\text{O}$  vapor ( $<300 \text{ ppm}$ ) on point-to-plane dc-corona inception and corona pulse characteristics in  $\text{SF}_6$  were investigated. Corona discharges were generated in short gaps, 1.0 to 3.0 cm, for sharp point electrodes of diameter  $\sim 0.1 \text{ mm}$ , and for gas pressures in the range of 100 to 400 kPa. Trace levels of  $\text{H}_2\text{O}$  were introduced by electrical heating of a wire in the gas, and its concentration was monitored with a gas chromatograph-mass spectrometer. Water vapor was found to significantly enhance the intensity of corona at a given voltage, as indicated by an order of magnitude or more increase in average discharge current and corona pulse rate. The presence of small quantities of  $\text{H}_2\text{O}$  greatly inhibits formation of positive streamer burst pulses and significantly modifies the shape of the corona pulse height distribution. On the other hand, introduction of  $\text{H}_2\text{O}$  results in only a slight reduction in the overall dielectric strength of  $\text{SF}_6$ .

21380. Berger, P. W. Complying with copyright in scientific libraries. The National Bureau of Standards experience, *J. Chem. Inf. Comput. Sci.* 22, No. 2, 74-78 (May 1982).



Key words: book prices; copyright law; inflation; interlibrary lending; journal prices; library photocopying; publishers.

Applying a "worst case" analysis of interlibrary borrowing in the NBS library for the years 1976-1979 demonstrates that the dangers of interlibrary lending to the interests of authors and publishers is slight compared to the clerical burden imposed on libraries by Sections 107 and 108 of the Copyright Law of 1976. Further, there is evidence of publisher, author, and library user disaffection with the law as well as instances of abuse by publishers of charges for photocopies of materials under copyright.

**21381.** Coffey, S.; Deprit, A. **Third-order solution to the main problem in satellite theory**, *J. Guid. Contr. Dyn.* 5, No. 4, 366-371 (1981).

Key words: artificial satellite; Hamiltonian; parallax transformation; third-order solution; transformation.

In the present paper we announce a completely analytic closed-form third-order solution to the main problem in the theory of an artificial satellite. This is the first time an analytic solution of the main problem has been produced to order 3 which is valid for satellites with any eccentricity  $0 < e < 1$ . The solution is accomplished by constructing a progression of three canonical transformations from the state variables to a set of action-angle variables in which the Hamiltonian for the problem is a function of the action variables only. The transformed Hamiltonian is developed, without omitting terms, to order 4 in the small parameter  $\epsilon = -J_2$ ; by way of verification it was found to agree through order 3 with the theory of Brouwer as extended by Kozai. The algebraic expressions for these transformations were produced by computer in a very compact form; conciseness is achieved in two ways, by eliminating the parallax and by controlling the computer automated calculations so as to avoid infinite series expansions in the eccentricity. Our programs prove that the main problem in satellite theory can be solved in closed form to order 3.

**21382.** Powell, C. J. **Comparison of ESCA with other surface-analysis techniques**, (Proc. Symp. Applied ESCA, 7th Annu. FACSS Meet., Philadelphia, PA, Oct. 2, 1980), Chapter 2 in *Applied Electron Spectroscopy for Chemical Analysis*, H. Windawi and F. Ho, eds., pp. 19-36 (John Wiley & Sons Inc., 1982).

Key words: Auger-electron spectroscopy; ESCA (electron spectroscopy for surface analysis); ion-scattering spectroscopy; secondary-ion mass spectroscopy; surface analysis; x-ray photoelectron spectroscopy.

ESCA (Electron Spectroscopy for Chemical Analysis) or x-ray photoelectron spectroscopy (XPS) is used extensively to solve a wide variety of scientific and technical problems. A short review is presented in which ESCA is compared and contrasted with three other techniques for surface analysis, Auger-electron spectroscopy (AES), secondary-ion mass spectroscopy (SIMS), and ion-scattering spectroscopy (ISS). Particular attention is given to the accuracy of measurement for both qualitative and quantitative analyses.

**21383.** Becker, D. A. **Recycling (oil)**, Paper in *Encyclopedia Chemical Technology 3d Edition*, 19, 979-985 (1982).

Key words: lubricants; oil recycling; petroleum; pollution control; reclaiming; re-refining; used oil; waste oil.

The term "oil" can include animal oils, vegetable oils, and synthetic oils as well as the usual mineral oil, produced from petroleum. An oil which has been used and/or contaminated, but not consumed, can often be recycled in order to regain a useful material regardless of its origin. Due a variety of reasons, there is increasing interest in developing ways to conserve the valuable energy and resource content of these oils through recycling. The article reviews the current developments in used oil recycling, and describes methods for recycling these oils into useful products, particularly lubricating oils.

**21384.** Seltzer, S. M.; Berger, M. J. **Status of electron transport cross sections**, *Trans. Am. Nucl. Soc.* 41, 477-478 (1982).

Key words: bremsstrahlung; cross sections; data base; electron; photon; transport.

In this paper, we highlight improvements to the cross-section data

base for various moderate- to high-energy Monte Carlo computer codes such as ETRAN, EGS, SANDYL, TIGER, etc., which are used to calculate the transport of electrons and associated bremsstrahlung at energies from  $\sim 10$  keV up to 1 GeV. We will indicate some work that we have completed, some which is still in progress, and some which may be desirable but for which we lack adequate information. The discussion will be in terms of the cross-section information needed by the ETRAN program, as supplied by the program DATAPAC, and will not involve, for example, collective effects associated with intense beams, cross sections in ionized media, and complications arising at energies  $\leq 1$  keV.

**21385.** Gross, J. **Summary of the NBS-NCSBCS Joint Conference on Building Rehabilitation Research and Technology for the 1980's**, *Proc. Building Rehabilitation Research and Technology for the 1980's*, San Francisco, CA, Dec. 12, 1979, pp. 308-312 (National Conference of States on Building Codes and Standards, Inc., 481 Carlisle Drive, Herndon, VA 22070, 1980).

Key words: building accessibility; building rehabilitation guidelines; code enforcement; earthquake requirements; energy conservation; existing buildings; rehabilitation.

This paper is the summary of a two-day technical conference, held on December 10-11, 1979, in San Francisco, California. It summarizes the twenty plus technical papers presented in four technical sessions, keynote address, and discussion of the HUD Rehabilitation Guidelines. The four technical sessions were: Building Code Development and Enforcement; Energy Conservation; Seismic Considerations and Solutions; Legal Implications and Economic Approaches.

It is to be published by the National Conference of States on Building Codes and Standards as part of the proceedings of this joint NBS-NCSBCS Conference.

**21386.** Blanc, R. P.; Heafner, J. F. **The NBS program in Computer Network Protocol Standards**, *Proc. Fifth Int. Conf. Computer Communications*, Atlanta, GA, Oct. 27-30, 1980, pp. 423-428 (North-Holland Publ. Co., 1980).

Key words: distributed computing; high level protocols; networking performance; network protocols; protocol standards; standards.

The National Bureau of Standards' program to develop standards for computer network protocols is described. A family of standards is expected to emerge from the program. They will form the basis for distributed computing in the Federal Government and will provide minimum cost, high performance networking to meet Federal needs. The program described includes a systematic approach to protocol development comprising design, implementation, and evaluation tasks. One objective is to develop standards that are consistent with national and international voluntary standards. To this end, the NBS work with voluntary standards organizations is described.

**21387.** Thomas, W. C.; Dawson, A. G., III; Waksman, D.; Streed, E. R. **Determination of incident angle modifiers for flat-plate solar collectors**, *Proc. ASME Solar Energy Division Fourth Annu. Conf.*, Albuquerque, NM, Apr. 26-29, 1982, W. D. Turner, ed., pp. 501-510 (American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017, 1982).

Key words: collector rating; incident angle modifier; measurement; solar collector; standards; thermal performance; uncertainty.

Existing test procedures for measuring and rating thermal performance require the determination of the angular response of collectors in order to account for non-normal incident beam irradiance. Angular response measurements for four different types of collectors, each type tested by three different laboratories, are presented and analyzed. Substantial differences, both within and between laboratories, are reported for the same type collectors. An analysis of the measurement procedure shows that experimentally determined angular response parameters are subject to relatively large uncertainties. The problem results to a large extent from measuring collector efficiencies at non-normal incident angles where measurement uncertainty is of the same order of magnitude as the efficiency reduction attributable to these off-normal angles. Other factors which can affect angular response measurements and the



method of correlating results are also discussed.

A theoretical analysis shows that shading of the absorber by the collector air space side and end walls for non-normal incident angles can be of the same order of importance as the decrease in the transmittance of the cover assembly. While this situation complicates an analytical approach, it is concluded that calculations are adequate to depict the angular response of conventional flat-plate tube-in-sheet collector designs. A simplified analytical procedure and nomographs are presented for rapid calculation of incident angle modifiers.

The predicted seasonal performance of solar energy systems and clear-day ratings of typical flat-plate collectors are shown to be relatively insensitive to large uncertainties in incident angle modifiers. Typically, the values of these calculated quantities could be affected by approximately five per cent as a result of uncertainty in the test-derived angular response parameter.

- 21388.** Lide, D. R., Jr. *Molecular spectroscopy*, *Encycl. Phys.*, pp. 613-618 (1981).

Key words: electronic spectra; infrared; microwave; molecular spectroscopy; rotational spectra; ultraviolet; vibrational spectra; visible.

An elementary description of molecular spectroscopy is presented. The correlation of types of spectra observed in different wavelength regions with features of molecular structure is described. A bibliography of other information sources is given.

- 21389.** Lide, D. R., Jr. *Quality control of data in the National Standard Reference Data System*, (Proc. 40th Annu. Meet. American Society for Information Science (ASIS), Chicago, IL, Sept. 26-Oct. 1, 1977), Paper in *Information Management in the 1980's*, 14, p. 117 (Knowledge Industry Publ. Inc., White Plains, NY, 1977).

Key words: chemical properties; critical tables; data evaluation; physical properties; reference data.

The National Standard Reference Data System comprises the set of data centers and other data evaluation projects administered or coordinated by the National Bureau of Standards. The primary aim of this program is to provide critically evaluated numerical data, in a convenient and accessible form, to the scientific and technical community of the United States. The technical scope of the program is restricted to well-defined physical and chemical properties of substances and systems which are well characterized. The program emphasizes quality control of the data. Experts in each field evaluate all data retrieved from the literature and present recommended values which represent the best professional judgment of the evaluators. The dissemination of such critical tables becomes increasingly important as the traditional disciplinary boundaries break down and users require data from fields outside their own technical competence.

- 21390.** Jach, T.; Powell, C. J. *Dependence of the 3p electron energy loss spectra of nickel on momentum transfer*, *Appl. Surf. Sci.* 11/12, 385-389 (1982).

Key words: ELS; energy loss spectroscopy; Fano effect; nickel.

The Fano lineshape of the threshold region in nickel 3p electron energy loss spectra is observed to change as the incident electron energy is lowered from 1000 to 150 eV. This change is attributed to changes in momentum transfer over the energy range investigated. The lineshape changes are consistent with a change of Fano's parameter  $q$  from 0.95 to 1.2, with significant deviations from the predicted Fano lineshape at the lowest incident energy. A satellite peak  $\sim 12$  eV above the 3p threshold is observed to decrease in intensity relative to the principal line.

- 21391.** Grimley, A. J.; Stephenson, J. C. *Evidence for sequential reactions in the CO<sub>2</sub> laser induced multiphoton dissociation of acetic anhydride and acetic acid*, *J. Chem. Phys.* 74, No. 1, 447-452 (Jan. 1, 1981).

Key words: carbene; hydroxyl; laser chemistry; laser excited fluorescence; molecular spectroscopy; multiphoton chemistry.

The CO<sub>2</sub> laser induced multiphoton dissociation of acetic acid and acetic anhydride has been investigated. We have observed the prompt formation of <sup>1</sup>CH<sub>2</sub> and OH by laser excited fluorescence and

determined their nascent rotational energy distributions. The rotational energy of each product was the same, regardless of which starting material was photolyzed. This observation leads us to propose a mechanism in which both the <sup>1</sup>CH<sub>2</sub> and the OH are formed by sequential up-pumping of molecular intermediates. We have also determined the yield versus fluence curves for both the  $\bar{a}$  (0,0,0) and  $\bar{a}$  (0,1,0) levels of <sup>1</sup>CH<sub>2</sub>. The relative yields of these two levels are found to change as a function of intensity.

- 21392.** Lovinger, A. J.; Davis, G. T.; Furukawa, T.; Broadhurst, M. G. *Crystalline forms in a copolymer of vinylidene fluoride and trifluoroethylene (52/48 mol %)*, *Macromolecules* 15, No. 2, 323-328 (Mar.-Apr. 1982).

Key words: crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer.

The structure of a 52/48 mol % copolymer of vinylidene fluoride and trifluoroethylene has been investigated at various temperatures by X-ray diffraction. Melt-solidified samples consist of a mixture of two disordered crystalline phases, one trans planar, the other 3/1 helical. Samples may be transformed to either phase by appropriate means to reveal a hexagonal (or pseudohexagonal) molecular packing. The all-trans phase may be obtained by drawing or poling at low temperatures; both treatments cause a transformation of the disordered mixture of phases into a well-ordered planar-zigzag phase. Isolation of the disordered 3/1-helical phase is achieved by heating to high temperatures, whereupon all samples, irrespective of orientation or polarization, undergo transformation to a poorly ordered helical structure analogous to that of trifluoroethylene homopolymer; upon cooling, the original, disordered mixture of phases is recovered.

- 21393.** Kaufman, V.; Sugar, J.; Cooper, D. F. *I and O I isoelectronic sequences: Observations of 2s<sup>m</sup>2p<sup>n</sup>-2s<sup>m-1</sup>2p<sup>n+1</sup> intersystem transitions and improved measurements for Cl, K, Ca, Sc, Ti, and V*, *Phys. Scr.* 25, No. 5, 623-626 (1982).

Key words: Ca XV; Cl XII; energy levels; K XIV; Sc XVI; Ti XVII; wavelengths; V XVIII.

Spectra of Cl through V (excluding Ar) were produced with a GW (15 ns) pulse from a Nd-glass laser impinging on solid targets and observed with a 10.7 m grazing incidence spectrograph. Strong 2s<sup>m</sup>2p<sup>n</sup>-2s<sup>m-1</sup>2p<sup>n+1</sup> transition arrays in the F I and O I isoelectronic sequences were recorded, from which intersystem lines were identified and improved wavelength measurements of allowed lines were made. Hartree-Fock calculations of the radial integrals were compared with those obtained from least squares fits of the newly derived energy levels to obtain improved predictions in the oxygen sequence by means of scaled Hartree-Fock integrals.

- 21394.** Becker, D. *Alternative utilization: Recycled oil used as fuel*, *Proc. Fourth Int. Conf. Used Oil Recovery and Reuse, Las Vegas, NV, Sept. 28-Oct. 1, 1981*, pp. 221-223 (Association of Petroleum Refiners, 2025 Pennsylvania Avenue, NW., Suite 1111, Washington, DC 20006, 1982).

Key words: burner fuel; fuel oil; petroleum; petroleum testing; processed used oil; recycled oil.

The National Bureau of Standards' (NBS) Recycled Oil Program issued a report on test procedures for use in evaluating used lubricating oil recycled for use as a burner fuel. This effort was in response to a Congressional mandate (P.L. 94-163, Section 383C) and was the first phase of a continuing effort to provide the technical basis for evaluating recycled petroleum oil products. While there is considerable controversy over which type of oil recycling (e.g., fuel vs. re-refining) is most appropriate, it is a fact that currently much of the used oil is burned as a fuel or fuel supplement. As a result of the NBS report (Technical Note 1130), there have been changes in the Federal Specification VV-F-815D to accommodate used oil recycled as fuel. This paper describes those changes and the NBS report they were based on.

- 21395.** Davis, G. T.; Furukawa, T.; Lovinger, A. J.; Broadhurst, M. G. *Structural and dielectric investigation on the nature of the transition in a copolymer of vinylidene fluoride and trifluoroethylene (52/48 mol %)*, *Macromolecules* 15, No. 2, 329-333 (Mar.-Apr. 1982).



**Key words:** chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion.

The effect of temperature on the structure and dielectric properties of a 52/48 mol % copolymer of vinylidene fluoride and trifluoroethylene has been investigated at temperatures up to 140°C. Undrawn or unpoled specimens contain an intimate mixture of two disordered crystalline phases, both of which undergo a large increase in  $d$  spacing at 65–70°C, with eventual transformation to a single phase in which the chains assume a disordered 3/1-helical conformation above 90°C. The 70°C transition is accompanied by a dielectric anomaly. High electric fields applied at temperatures below 70°C induce a phase change to a single, well-ordered all-trans conformation, leading to remanent polarization with piezoelectric and pyroelectric coefficients comparable to those of poly(vinylidene fluoride). The changes in crystal phase and dipole orientation upon poling result in a reduction of the dielectric constant at room temperature, a shift of the dielectric anomaly to ~80°C, stability of the all-trans crystal phase to somewhat higher temperatures, and a discrete change in  $d$  spacing to that of the disordered 3/1-helical conformation at the transition region. The loss of polarization in poled specimens at this ferroelectric-to-paraelectric transition is attributable primarily to the molecular change from the polar all-trans conformation to its nonpolar, disordered 3/1-helical counterpart, as well as to the onset of rotational dipolar motions leading to the dielectric anomaly.

**21396.** Geist, J.; Gladden, W. K.; Zalewski, E. F. Physics of photon-flux measurements with silicon photodiodes, *J. Opt. Soc. Am.* 72, No. 8, 1068-1075 (Aug. 1982).

**Key words:** collection efficiency; quantum efficiency; quantum yield; silicon photodiode; spectral response.

A model of the quantum efficiency of a planar silicon photodiode that is useful in connection with high-accuracy optical-radiation measurements is developed. The model is based mostly on macroscopic (phenomenological) optical and electronic properties of the device that must be determined from experiments on the device, but the connection with the microscopic physical properties (band structure) of silicon is made. The predictions of this model differ significantly from recent experimental results for the variation of the internal quantum efficiency with angle for a silicon photodiode as reported by Durnin *et al.* [*J. Opt. Soc. Am.* 71, 115 (1981)]. A repetition of these measurements is described. The results do not agree with those reported by Durin *et al.* but do agree well with the predictions of the quantum-efficiency model.

**21397.** Becker, D. A. NBS research on re-refined engine oil tests, *Proc. Fourth Int. Conf. Used Oil Recovery and Reuse, Las Vegas, NV, Sept. 28-Oct. 1, 1981*, pp. 300-303 (Association of Petroleum Re-Refiners, 2025 Pennsylvania Avenue, NW., Suite 1111, Washington, DC 20006, 1982).

**Key words:** additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; petroleum; petroleum testing; recycled oil; re-refining; used oil recycling.

The National Bureau of Standards' Recycled Oil Program has been developing and evaluating test procedures for re-refined engine oils for several years, in response to a Congressional mandate (P.L. 94-163, Section 383c). The strategy we have adopted is to attempt to provide a set of test procedures capable of adequately monitoring the consistency and additive response characteristics of the re-refined petroleum lubricating oil basestocks. These basestock tests will then be coupled with appropriate engine sequence testing. Progress in the evaluation of chemical and physical test procedures has been steady significant progress in research on bench tests for additive response has also been made. Progress in these areas are described in the paper.

**21398.** Berger, H.; Birnbaum, G.; Eitzen, D. G. NDT measurements traceable to NBS, *Proc. Tenth World Conf. Non-Destructive Testing, Moscow, USSR, Aug. 23-28, 1982*, pp. 58-65 (1982).

**Key words:** acoustic emission; calibration; leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; radiography; standards; traceable measurements; visual testing.

Many nondestructive testing (NDT) measurements are now traceable through calibrations or Standard Reference Materials (SRM's) available from the National Bureau of Standards (NBS). The NDT areas involved include acoustic emission, x-ray and neutron radiography, eddy current, magnetic particles, liquid penetrants, visual acuity testing and leak rate measurements.

**21399.** Wong, Y. M.; Meijer, P. H. E. Simple extension of Suzuki's scaling approach to the onset time of an unstable state: Application to supercooled liquid, *Phys. Rev. A* 26, No. 1, 611-616 (July 1982).

**Key words:** nonlinear; relaxation; supercooling; Suzuki's scaling; time-dependent growth rate; unstable.

Motivated by the experimental findings of the onset time of a supercooled liquid, we extend Suzuki's scaling method to include the case of a time-dependent externally controlled growth rate. The simple application of this modified nonlinear-time-scale transformation leads to the following predictions: the deeper one quenches the sample, or the longer one waits before heating the sample, or the more the heating of the sample, the shorter the onset time of the freezing process. Its inadequacy to explain the quench-rate dependence of the onset time suggests that a similar examination of a two-mode theory may be the key to the behavior of the fusion phenomenon of supercooled liquid.

**21400.** O'Connell, J. S. Measuring nucleon charge and magnetization inside the nucleus, *Comments Nucl. Part. Phys.* XI, No. 1, 1-7 (1982).

**Key words:** charge magnetization; Coulomb sum rule; electron scattering; Fermi gas model; nuclear response function; nuclei; nucleons; quasi-free.

Deep inelastic scattering of electrons on nuclei measures the response to probes of the nucleon charge and magnetization inside nuclear matter. Recent data show response functions whose shape and area are not in agreement with standard theoretical models.

**21401.** Prince, E. Comparison of the fits of two models to the same data set, *Acta Crystallogr. B* 38, 1099-1100 (1982).

**Key words:** comparison of models; linear regression; neutron diffraction; powder refinement; significant differences; statistical analysis.

A frequently encountered problem is the determination of whether one model gives a significantly better fit to a set of data than another. This may be studied by examining the correlation between the differences in the predictions of the models and the corresponding differences between the observed data and the arithmetic means of the predictions. The existence and precision of such correlations may be determined using the techniques of linear regression. The analysis has been applied to a neutron powder diffraction study of the defect structure of nonstoichiometric lithium tantalate.

**21402.** Lightbody, J. W., Jr. Spectrometer requirements for ( $e, e'2N$ ) studies, *Proc. Workshop High-Resolution, Large-Acceptance Spectrometers, Argonne National Laboratory, Argonne, IL, Sept. 8-11, 1981, Section IV*, pp. J-1—J-10 (Available from the National Technical Information Service, Springfield, VA 22161, 1982).

**Key words:** momentum acceptance; nucleon; pair correlation function; resolution; solid angle; spectrometer.

The kinematics and dynamics of the ( $e, e'2N$ ) reaction is discussed in terms of spectrometer requirements. The range of momentum transfer over which one can reasonably access the pair correlation is given. An experimental configuration is described which requires a single spectrometer for detecting both nucleons.

**21403.** Serbyn, M. R.; Penzes, W. B. A real-time vibration controller, *ISA Trans.* 21, No. 3, 55-59 (1982).

**Key words:** active vibration control; Michelson interferometer; optical path-length correction; phase comparator; real-time control; vibration control; vibration isolation.



The Michelson interferometer is viewed as a noisy system whose noise input results from unwanted changes in the optical path lengths of its beams, and whose desired output is a constant optical path-length difference. A technique for maintaining this quality at a value equal to a multiple of quarter wavelengths of the light is described.

**21404.** Gans, W. L.; Nahman, N. S. Continuous and discrete Fourier transforms of steplike waveforms, *IEEE Trans. Instrum. Meas.* IM-31, No. 2, 97-101 (June 1982).

Key words: discrete Fourier transform; Fourier analysis; waveform.

A steplike waveform which has attained its final value is converted into a duration-limited one which preserves the spectrum of the original waveform and is suitable for discrete Fourier transform (DFT) computations. The method, which is based upon the response of a time-invariant linear system excited by a rectangular pulse of suitable duration, is first applied to continuous waveforms and then to discrete (sampled) waveforms. For completeness, the difference (error) between the spectra of a continuous waveform and a discrete representation of it are reviewed.

**21405.** Giampapa, M. S.; Golub, L.; Rosner, R.; Vaiana, G. S.; Linsky, J. L.; Worden, S. P. A Heating mechanism for the chromospheres of M dwarf stars, (Proc. Second Cambridge Workshop Cool Stars, Stellar Systems, and the Sun, Cambridge, MA, Oct. 21-23, 1982), *Special Report No. 392*, 73-79 (Smithsonian Astrophysical Observatory, Cambridge, MA, 1982).

Key words: flare stars; late-type stars; stellar chromospheres; stellar coronae; ultraviolet spectra.

Our preliminary investigation corroborates the suggestion by Cram (1981) that X-ray heating by an overlying corona is the dominant heating mechanism in dMe stellar chromospheres. Of course this does not entirely resolve the problem of the heating of M dwarf atmospheres since the question concerning the origin of the X-ray emission itself (i.e., coronal heating) still remains. Nevertheless, the identification of a dominant chromospheric heating mechanism for a particular class of stars is a significant advance for the understanding of the origin of stellar chromospheres. The importance of X-ray heating in other stellar types should be assessed by comparing the observed total chromospheric-transition region line luminosities with the observed X-ray luminosities for sets of "active" and "quiet" stars of various spectral types. Interestingly, X-ray heating appears important in that region of the H-R diagram where turbulent velocities are low. We therefore speculate that for earlier stellar types, characterized by higher turbulent velocities, direct heating of the stellar chromosphere by magneto-acoustic mechanisms (e.g., see Ulmschneider and Bohn 1981; Leibacher and Stein, this conference) becomes relatively more important than external heating by coronal X-rays.

**21406.** Fattal, S. G.; Reinhold, T. A.; Ellingwood, B. Analysis of thermal stresses in internally sealed concrete bridge decks, *Federal Highway Administration Research Report No. FHWA/RD-80/085*, 116 pages (Available from the National Technical Information Service, Springfield, VA 22161, 1981).

Key words: bridge deck; concrete; construction methods; cracking; finite element analysis; heat treatment; structural design; thermal analysis; thermal stress.

A structural analysis program is prepared to predict thermal stresses which result from the application of heat blankets to concrete decks of highway bridges. The decks are heated to obtain an internally sealed concrete so as to better protect the reinforcement from corrosion. Simple decks are first studied to determine the sensitivity of the solutions to various modeling assumptions. Two full scale bridge decks are also analyzed for which the temperature distributions are predefined on the basis of field data. The program will provide a helpful tool which will enable future field measurements to be planned more selectively. It will also provide insight on means for improving the heat treatment process so as to minimize cracking damage.

**21407.** Yaniv, S. L.; Danner, W. F.; Bauer, J. W. Measurement and prediction of annoyance caused by time-varying highway noise, *J. Acoust. Soc. Am.* 72, No. 1, 200-207 (July 1982).

Key words: duration; laboratory psychoacoustics; measurement of adverse response to noise; noise criteria; noise indices; time-varying highway noise.

Twenty-eight audiologically normal adult subjects participated in a study designed to assess how well six noise-rating indices would predict the annoyance caused by 3-min recorded samples of traffic noise obtained from both nominally constant-speed and stop-and-go traffic. The study was performed in a laboratory simulating a home environment. Annoyance judgments were obtained through the use of a magnitude estimation technique involving a 10-point scale. Subjects were also asked if they could accept each of the 24 traffic sounds if heard on a regular basis in their homes. Data obtained indicate that the simpler noise-rating indices, such as the average sound level and the level exceeded 10% of the time, predict annoyance as well as, if not better than, complicated schemes incorporating a measure of either variability or rate-of-change of levels with time. Thus it appears that the measurement and computational burdens associated with these complicated schemes are unwarranted.

**21408.** Diller, D. E. Measurements of the viscosity of saturated and compressed liquid propane, *J. Chem. Eng. Data* 27, No. 3, 240-243 (July 1982).

Key words: density dependence; isothermal measurements; liquid propane; quartz crystal viscometer; saturated liquid; shear viscosity coefficient.

The shear viscosity coefficient of saturated and compressed liquid propane has been measured with a torsionally oscillating quartz crystal viscometer at temperatures between 90 and 300 K and at pressures up to 30 MPa (4350 psia). The estimated precision and accuracy of the measurements are about 1% and 2%, respectively. The measurements have been compared with an equation previously optimized to available data and proposed for calculating the viscosity of compressed gaseous and liquid propane at temperatures down to 140 K. Differences between the equation and the measurements reported here are within our experimental error at temperatures above 140 K. Differences between our measurements and the equation extrapolated to temperatures below 140 K increase with decreasing temperature (and increasing density) to about 30% at 90 K.

**21409.** Fickett, F. R. Electrical and magnetic properties of internally oxidized copper and dilute copper-iron alloys, *J. Phys. F Met. Phys.* 12, 1753-1769 (1982).

Key words: alloy; copper; electrical property; iron; low temperature; magnetic property; oxidation.

The results of several years of work devoted to developing an understanding of the process by which the resistive contribution of transition metal impurities, primarily iron, in copper is removed by internal oxidation are presented. The majority of the investigations were made on a CuFe alloy series of precisely determined composition from 1 to 100 atomic parts per million (at PPM) Fe. Electrical resistance and magnetic susceptibility measurements at room temperature and at 4 K on both unoxidized and oxidized samples are reported. These measurements, supported by scanning electron microscopy (SEM) and Curie temperature determinations, suggest a two-step internal oxidation process at even the lowest impurity levels.

**21410.** Cezairliyan, A.; Morse, M. S.; Foley, G. M.; Erickson, N. E. Microsecond resolution pulse heating technique for thermophysical measurements at high temperatures, *Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Washington, DC, June 15-18, 1981*, pp. 45-50 (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1982).

Key words: dynamic methods; high temperature; pulse electrical measurements; pyrometry; refractory materials.

The status of the development of a dynamic technique for the accurate measurement of selected thermophysical properties (such as heat capacity, electrical resistivity, temperature and energy of phase



transformations) of electrically conducting materials in their solid and liquid phases at high temperatures (above 2000 K) is presented. The method is based on rapid (in less than one millisecond) resistive self-heating of the specimen by passing a high current pulse through it and measuring both the power imparted to the specimen (obtained by measuring current through and voltage across the specimen) and the specimen temperature. Current and voltage are measured with the use of pulse transformers. Specimen temperature is measured with a photoelectric pyrometer capable of making radiance temperature determinations at two wavelengths (0.65 and 0.9  $\mu\text{m}$ ). The analog signals corresponding to current, voltage and two radiance temperatures are digitized and recorded simultaneously with a digital data acquisition system every 1.5  $\mu\text{s}$  with a resolution of about 0.1% of full scale. Performance of the system is discussed, and examples of energy and temperature measurements under dynamic conditions are presented.

**21411.** Hanley, H. J. M.; Evans, D. J.; Hess, S. *Theory of fluids via computer simulation: Structure under shear*, *Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Washington, DC, June 15-18, 1981*, pp. 326-330 (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1982).

Key words: computer simulation; local mole fraction; mixtures; non-Newtonian behavior; radial distribution function; shear; soft sphere.

The technique of nonequilibrium molecular dynamics is used to simulate the structure of a binary mixture of soft spheres in equilibrium and in nonequilibrium under shear. Radial distribution functions are reported for the system at two-thirds melting for mixtures with a large difference in the mass and size of the species. Results are also given for the radial distribution function under shear for the pure soft sphere fluid close to melting. Non-Newtonian and normal pressure difference phenomena are observed.

**21412.** Diller, D. E. *Measurements of the viscosity of saturated and compressed liquid methane, ethane and propane*, *Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Washington, DC, June 15-18, 1981*, pp. 219-226 (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1982).

Key words: density dependence; ethane; isothermal measurements; methane; propane; quartz crystal viscometer; saturated liquid; shear viscosity coefficient.

The shear viscosity coefficients of saturated and compressed liquid methane, ethane and propane have been measured at temperatures between 90 and 300 K, and at pressures to 30 MPa (4350 psia) with a torsionally oscillating quartz crystal viscometer. The measurements extend the range of previous low temperature measurements to higher pressures and densities. For propane the reduced temperature range extends down to about 0.24  $T_c$  and the reduced density range extends up to about 3.3  $\rho_c$ . The estimated precision and accuracy of the measurements are about one percent and two percent respectively. The measurements have been compared with equations previously proposed for calculating the shear viscosity coefficients of these fluids. Differences between the measured and calculated viscosities are discussed.

**21413.** Van Degriest, C. T.; Bowers, W. J., Jr.; Pipes, P. B.; McQueeney, D. F. *Contribution of nuclear magnetism to the isochoric pressure of bcc solid  $^3\text{He}$* , *Phys. Rev. Lett.* **49**, No. 2, 149-153 (July 12, 1982).

Key words: magnetostriction; nuclear magnetism; pressure measurements; solid  $^3\text{He}$ .

Isochoric pressure measurements have been made in bcc solid  $^3\text{He}$  from the melting point down to 29 mK in magnetic fields up to 8.0 T and for molar volumes of 23.834, 24.163, and 24.371 ml/mole. The measurements show that the pressure at high magnetic fields is thermodynamically inconsistent with reported values for the Weiss temperature deduced from nuclear magnetic susceptibility. Furthermore, the Weiss temperature deduced from our data at 24.25 ml/mole is in disagreement with that used in the theory of Roger, Hetherington, and Delrieu.

**21414.** Nieto de Castro, C. A.; Roder, H. M. *Thermal conductivity of argon at 300.65 K. Evidence for a critical enhancement?*, *Proc. 8th Symp. Thermophysical Properties, National Bureau of Standards, Washington, DC, June 15-18, 1981*, pp. 241-246 (American Society of Mechanical Engineers, New York, NY, 1982).

Key words: ambient temperature; argon; critical enhancement; hard sphere; hot wire; thermal conductivity; transient.

Recent measurements of the thermal conductivity of argon at room temperature and pressures up to 70 MPa have shown an unexpected behaviour of the thermal conductivity versus density plot, a small abnormality around the critical density.

The existing theories of the transport properties near the critical state do not show any significant enhancement for  $\Delta T^* > 0.3$  within the accuracy of thermal conductivity measurements so far reported.

The data obtained by the authors for argon at 300.65 K or  $\Delta T^* = 0.99$  with an estimated accuracy of  $\pm 1\%$  seem to support the existence of an enhancement of the order of 2% near the critical density. We emphasize that the enhancement is relatively small, i.e., of the same order of magnitude as the experimental precision and accuracy. A detailed polynomial analysis of our data has been combined with an analysis of existing data for argon for  $0.068 < \Delta T^* < 1$  near the critical density. An exponent more negative than -0.63 was found for the temperature derivative of the thermal conductivity enhancement if we use the scaling law formulation and extrapolate it to this higher temperature.

**21415.** Linsky, J. L. *The structure, energy balance, and winds of cool stars*, *Proc. Third European IUE Conf., Madrid, Spain, May 10-13, 1982*, pp. 3-13 (European Space Agency, 75738 Paris Cedex 15, France, 1982).

Key words: late-type stars; stellar chromospheres; stellar coronae; ultraviolet spectra; x-ray sources.

A broad theme emerging from IUE observations of cool stars is that magnetic fields control the structure and energy balance of the outer atmospheres of these stars. I summarize the phenomena associated with magnetic fields in the Sun and show that similar phenomena occur in cool stars. High dispersion spectra are providing unique information concerning densities, atmospheric extension, and emission line widths. A recent unanticipated discovery is that the transition lines are redshifted (an antiwind) in  $\beta$  Dra (G2 Ib) and perhaps other stars, which I interpret as indicating downflows in closed magnetic flux tubes as are seen in the solar flux tubes above sunspots. Finally, I classify the G and K giants and super-giants into three groups—active stars, quiet stars, and hybrid stars—depending on whether their atmospheres are dominated by closed magnetic flux tubes, open field geometries, or a predominately open geometry with a few closed flux tubes embedded.

**21416.** Rainwater, J. C.; Holland, P. M.; Biolsi, L. *Numerical calculation of gaseous transport properties from the Hulburt-Hirschfelder potential with applications to planetary entry thermal protection*, *Prog. Aeronaut. Astronaut.* **82**, 3-16 (1982).

Key words: ablation products; binary collision dynamics; gaseous carbon; Hulburt-Hirschfelder potential; numerical integration; orbiting collisions; thermal conductivity; viscosity.

Transport properties of dilute monatomic gases have been evaluated by means of the Hulburt-Hirschfelder (H-H) potential, which contains nonadjustable parameters determined completely from spectroscopic data. The H-H potential is shown to encompass five distinct patterns of binary collision dynamics, some of which include double orbiting. Since the collision dynamics are more complicated than those of commonly used potentials such as the Lennard-Jones, the numerical routines to evaluate Chapman-Enskog collision integrals have been extensively revised. For applications to thermal protection during entry into atmospheres of the outer planets, transport properties of monatomic carbon gas at  $T \sim 10^4$  K have been evaluated.

**21417.** Radebaugh, R. *Kapitza resistance*, *McGraw-Hill Encycl. Sci. Technol.* **5**, No. 2, 466-467 (Apr. 1982).

Key words: heat transfer; Kapitza conductance; Kapitza resistance; liquid helium; surface effect.



The Kapitza thermal boundary resistance between a solid and liquid helium is defined and explained briefly.

- 21418.** Van Poolen, L. J.; Haynes, W. M. New approach for analysis and prediction of liquid-vapor coexistence densities including the critical region, (Proc. 1981 Cryogenic Engineering Conf., San Diego, CA, Aug. 11-14, 1981), Paper in *Adv. Cryog. Eng.* 27, 839-847 (Plenum Press, New York, 1982).

Key words: coexistence densities; critical density; critical point; liquid volume fraction; pure fluids.

The use of the liquid volume fraction to analyze the internal consistency of saturated liquid and vapor densities in relation to the critical density is described. Its use in calculating saturation densities in regions in which accurate data are unavailable and in determining a critical density consistent with available coexistence boundary data is also reported. Applications of this new approach to available literature data are presented.

- 21419.** Sobha, K. V.; Agarwal, G. S. Effect of spatial dispersion on the classical field enhancement factors near a rough surface, *Solid State Commun.* 43, No. 2, 99-103 (1982).

Key words: electromagnetic scattering; rough surfaces; spatial dispersion.

Effect of spatial dispersion on the classical field enhancement factors near a rough surface is studied in detail for two different types of the material medium—(i) metallic medium in hydrodynamic approximation, (ii) excitonic medium in the effective mass approximation. A general perturbation approach based on Ewald-Oseen extinction theorem is used to obtain fields to different orders in the surface roughness parameter. Numerical results indicate that spatial dispersion could have significant effect on the resonant enhancement of local fields.

- 21420.** Cooper, J.; Ballagh, R. J.; Burnett, K.; Hummer, D. G. On redistribution and the equations for radiative transfer, *Astrophys. J.* 260, No. 1, 299-316 (Sept. 1, 1982).

Key words: collisional broadening; frequency redistribution; line broadening; radiative transfer; spectral line formation.

We outline the derivation of the equations of statistical equilibrium, starting from the quantum density-matrix equations, drawing particular attention to the approximations and assumptions used in the development of tractable expressions. Then, using the quantum-fluctuation-regression theorem, we obtain emission and absorption coefficients for multilevel atomic systems which are nondegenerate except for  $m$ -substates (thus excluding hydrogen). These coefficients are valid to first order in the incident intensity. We also suggest possible extensions to higher intensity broadband incoherent fields. A summary of the most important results is given at the end of the paper.

- 21421.** Linsky, J.; Boggess, A.; Bowyer, S.; Caldwell, J.; Cash, W.; Cohen, J.; Dupree, A.; Green, R.; Jenkins, E.; Jura, M.; Leckrone, D.; Moos, H. W.; Savage, B.; Shull, M.; Snow, T.; Timothy, J. G.; Weiler, E.; York, D. Current NASA studies for a Far-Ultraviolet Spectrographic Explorer (FUSE), *Proc. Third European IUE Conf., Madrid, Spain, May 10-13, 1982*, pp. 473-485 (ESA Scientific and Technical Publications, ESTEC, Noordwijk, The Netherlands, June 1982).

Key words: cool stars; extragalactic astronomy; extreme ultraviolet spectroscopy; galactic astronomy; grazing-incidence optics; hot stars; interstellar medium; solar system astronomy.

This report summarizes the current status of planning by a NASA science working group for the proposed Far-Ultraviolet Spectrographic Explorer (FUSE). These plans are still far from complete and may be modified greatly before a final report is completed, but they envision a satellite to obtain spectra with resolutions ( $\lambda/\Delta\lambda$ ) between  $1 \times 10^5$  and 100 in the spectral regions 912 Å to somewhat longer than 1216 Å and 100-912 Å. This report summarizes the important new scientific problems that can be studied by FUSE, but cannot be addressed by IUE or ST, which are sensitive only to wavelengths longward of 1200 Å. We also describe two new optical designs—a grazing incidence echelle and a hybrid echelle—to

accomplish these scientific goals with high throughput, large simultaneous spectral range, and low background photon-counting statistics. We envision FUSE to be an international collaborative satellite operated in a guest investigator mode like IUE.

- 21422.** Tilford, C. R. Sensitivity of commercial ion gage tubes, *Proc. 9th Symp. Engineering Problems of Fusion Research, Chicago, IL, Oct. 26-29, 1981*, pp. 1924-1927 (Institute of Electrical and Electronics Engineers, New York, NY, 1981).

Key words: Bayard and Alpert gage; gage sensitivity; ion gages; relative sensitivity; triode gage; vacuum gages.

Fusion science and engineering requires an increasing number of accurate vacuum measurements. In order to determine what level of performance can be expected from different ion gages a gage characterization program has been initiated. This program determines the uniformity, accuracy, and linearity for different gage tubes, and for the more promising candidates further characterizes the sensitivity for different gases and the effects of changing bias voltages and emission currents. Results to date show the best performance from conventional triode and tubulated Bayard/Alpert gages with tungsten filaments. Significantly poorer results are obtained from nude Bayard/Alpert gages and gages with thoriated iridium filaments.

- 21423.** Jacox, M. E. The reaction of F atoms with acetaldehyde and ethylene oxide. Vibrational spectra of the  $\text{CH}_3\text{CO}$  and  $\text{CH}_2\text{CHO}$  free radicals trapped in solid argon, *Chem. Phys.* 69, 407-422 (1982).

Key words: acetaldehyde; acetyl; ethylene oxide; F-atom reactions; formyl methyl; HF; hydrogen bonding; infrared spectrum; matrix isolation; photolysis.

When the products of the reaction with acetaldehyde of F atoms produced in a microwave discharge are frozen in a large excess of argon at 14 K, infrared absorptions of the  $\text{CH}_3\text{CO}$  and  $\text{CH}_2\text{CHO}$  free radicals and of their hydrogen-bonded complexes with HF appear. The  $\text{CH}_2\text{CHO}$  absorptions are also present in similar studies of the reaction of F atoms with ethylene oxide. The products of secondary F-atom reactions play minor roles under the conditions of these experiments. Detailed isotopic substitution studies support the free radical and HF complex identifications and demonstrate that the chemical bonding in the ground state of  $\text{CH}_2\text{CHO}$  is appropriate to the formyl methyl ( $\text{H}_2\text{C}-\text{CH}=\text{O}$ ) rather than the vinoxyl ( $\text{H}_2\text{C}=\text{CH}-\text{O}$ ) structure. The vibrational assignment of formyl methyl is compared with that of vinyl fluoride. The acetyl radical photodecomposes into  $\text{CH}_3 + \text{CO}$  in the visible spectral region. The photodecomposition threshold of the formyl methyl radical lies between 280 and 300 nm, with  $\text{CH}_3$  and CO as the products.

- 21424.** Pfrang, E. O.; Marshall, R. Collapse of the Kansas City Hyatt Regency walkways, *Civ. Eng.* 52, No. 7, 65-68 (July 1982).

Key words: building; collapse; connection; construction; failure; steel; walkway.

An investigation into the collapse of two suspended walkways within the atrium area of the Hyatt Regency Hotel in Kansas City, MO, is presented in this report. The investigation included on-site inspections, laboratory tests and analytical studies.

Three suspended walkways spanned the atrium at the second, third, and fourth floor levels. The second floor walkway was suspended from the fourth floor walkway which was directly above it. In turn, this fourth floor walkway was suspended from the atrium roof framing by a set of six hanger rods. The third floor walkway was offset from the other two and was independently suspended from the roof framing by another set of hanger rods. In the collapse, the second and fourth floor walkways fell to the atrium floor with the fourth floor walkway coming to rest on top of the lower walkway.

Based on the results of this investigation, it is concluded that the most probable cause of failure was insufficient load capacity of the box beam-hanger rod connections. Observed distortions of structural components strongly suggest that the failure of the walkway system initiated in the box beam-hanger rod connection on the east end of the fourth floor walkway's middle box beam.

Two factors contributed to the collapse: inadequacy of the original design for the box beam-hanger rod connection which was identical for all three walkways, and a change in hanger rod arrangement during construction that essentially doubled the load on the box beam-hanger rod connections at the fourth floor walkway. As originally



approved for construction, the contract drawings called for a set of continuous hanger rods which would attach to the roof framing and pass through the fourth floor box beams and on through the second floor box beams. As actually constructed, two sets of hanger rods were used, one set extending from the fourth floor box beams to the roof framing and another set from the second floor box beams to the fourth floor box beams.

Based on measured weights of damaged walkway spans and on a videotape showing occupancy of the second floor walkway just before the collapse, it is concluded that the maximum load on a fourth floor box beam-hanger rod connection at the time of collapse was only 31 percent of the ultimate capacity expected of a connection designed under the Kansas City Building Code. It is also concluded that had the original hanger rod arrangement not been changed, the connection capacity would have been approximately 60 percent of that expected under the Kansas City Building Code. With this change in hanger rod arrangement, the load capacity of the walkways was so significantly reduced that, from the day of construction, they had only minimal capacity to resist their own weight and had virtually no capacity to resist additional loads imposed by people.

- 21425.** Rainwater, J. C.; Holland, P. M.; Biolsi, L. Binary collision dynamics and numerical evaluation of dilute gas transport properties for potentials with multiple extrema, *J. Chem. Phys.* 77, No. 1, 434-447 (July 1, 1982).

Key words: binary collisions; Chapman-Enskog; collision integrals; Hulbert-Hirschfelder potential; numerical integration; orbiting; thermal conductivity; viscosity.

Prediction of gaseous transport properties requires calculation of Chapman-Enskog collision integrals which depend on all possible binary collision trajectories. The interparticle potential is required as input, and for a variety of applications involving monatomic gases the Hulbert-Hirschfelder potential is useful since it is determined entirely from spectroscopic information and can accommodate the long-range maxima and minima found in many systems. Hulbert-Hirschfelder potentials are classified into five distinct types according to their qualitative binary collision dynamics, which in general can be quite complex and can exhibit "double orbiting," i.e., a pair of orbiting impact parameters for a single energy of collision. The collision integral program of O'Hara and Smith has been revised extensively to accommodate all physical cases of the Hulbert-Hirschfelder potential, and the required numerical methods are described and justified. The revised program substantially extends the range of potentials for which collision integrals can be calculated.

- 21426.** Free, G.; Birnbaum, G.; Berger, H.; Kljuev, V.; Fedosenko, Y. Standards for eddy current nondestructive testing, *Proc. Tenth World Conf. Non-Destructive Testing, Moscow, USSR, Aug. 26, 1982*, pp. 261-266 (Aug. 1982).

Key words: ASTM standards; eddy current; electro; electromagnetic sorting; nondestructive testing; nonferrous metals; standardizing equipment; standards; USSR standards.

In order to provide a basis for intercomparison of procedural standards in the field of eddy-current testing, several standards of the United States voluntary standards organization ASTM and of the Soviet Union standards organization, GOST, are identified. A brief description is provided of the contents of each of these standards.

- 21427.** Haynes, W. M.; Younglove, B. A. Dielectric constants of saturated liquid propane, isobutane, and normal butane, (Proc. 1981 Cryogenic Engineering Conf., San Diego, CA, Aug. 11-14, 1981), Paper in *Adv. Cryog. Eng.* 27, 883-891 (1982).

Key words: Clausius-Mossotti function; dielectric constant; isobutane; normal butane; propane; saturated liquid; saturated vapor.

Measurements of the dielectric constants of saturated liquid propane (90-300 K), isobutane (115-303.15 K), and normal butane (135-303.15 K) are presented. The overall uncertainty of these measurements is estimated to be approximately 0.01 percent. By combining these dielectric constant data with density data previously obtained with a magnetic suspension densimeter in the same laboratory, the Clausius-Mossotti (CM) function is determined. A simple analytical expression is used to represent the CM function over wide ranges of temperature and density. Comprehensive comparisons

with other experimental data are given.

- 21428.** Bender, P. L. Scientific goals of laser range measurements, *Proc. Fourth Int. Workshop Laser Ranging Instrumentation, Austin, TX, Oct. 12-16, 1981*, pp. 502-511 (Geodetic Institute, University of Bonn, Bonn, Germany, 1982).

Key words: geodesy; geodynamics; laser ranging; plate tectonics; space techniques.

Two of the most important areas of geodynamics to which laser ranging appears capable of making fundamental contributions are discussed. These are worldwide plate tectonic motion measurements and the monitoring of the longer wavelength crustal movements in seismic zones. In both areas, the accuracy and reliability of the results are of great importance, since a factor 2 improvement in accuracy can reduce the time necessary for detecting anomalous motions by the same factor. The capabilities of other techniques are discussed briefly, and it is argued that laser ranging to satellites is likely to make major and unique contributions to geodynamics if it succeeds in demonstrating higher measurement accuracy than radio techniques. A strong emphasis on improving the measurement accuracy thus appears to be needed during the next two years.

- 21429.** Brown, P. W.; Masters, L. W. Factors affecting the corrosion of metals in the atmosphere, *Atmos. Corros.*, pp. 31-49 (1982).

Key words: atmospheric corrosion; chlorides; particulates; relative humidity; sulfates; weathering factors.

The durability of materials is dependent, to a large extent, on the in-service environment to which they are exposed; thus, the prediction of durability requires knowledge of the service environment. Weathering factors, which comprise one group of environmental factors, are the subject of this report.

From the standpoint of assessing the resistance of a metal to atmospheric corrosion, the characterization of the in-service environment is essential. The environmental factors of importance in durability testing can be divided into factors relating to: 1) weathering, 2) biological organisms, 3) stress, 4) incompatibility, and 5) use. Weathering factors include solar radiation, temperature, water, normal air constituents, air contaminants, and wind. Biological factors are manifold and may include the effects of a variety of life forms. Stress factors may be sustained or periodic. Incompatibility factors may be due to deleterious interactions between adjoining or neighboring materials. Use factors reflect misuse or abuse and the normal wear of materials. The effects of the five classes of environmental factors are not independent and substantial interaction between them is observed.

The effects of environmental factors on atmospheric corrosion are discussed with emphasis placed on weathering factors. Climatological data along with data on the abundance of pollutants are presented.

- 21430.** Itano, W. M.; Wineland, D. J. Laser cooling and double resonance spectroscopy of stored ions, (Proc. Fifth Int. Conf. Laser Spectroscopy, Jasper Park Lodge, Alberta, Canada, June 29-July 3, 1981), Paper in *Laser Spectroscopy V*, A. R. W. McKellar, T. Oka, and B. P. Stoicheff, eds., 30, 361-368 (Springer-Verlag, Berlin, Heidelberg, 1981).

Key words: atomic frequency standards; atomic hyperfine structure;  $Hg^+$ ; laser cooling;  $Mg^+$ ; optical pumping; stored ions.

Experiments are described in which  $Mg^+$  ions stored in a Penning trap are cooled by resonant light pressure and optically pumped. Double resonance detection of transitions with high efficiency is described. Applications of these techniques to frequency and time standards are discussed.

- 21431.** Haynes, W. M. Measurements of orthobaric-liquid densities of multicomponent mixtures of LNG components ( $N_2$ ,  $CH_4$ ,  $C_2H_6$ ,  $C_3H_8$ ,  $CH_3CH(CH_3)CH_3$ ,  $C_4H_{10}$ ,  $CH_3CH(CH_3)C_2H_5$ , and  $C_5H_{12}$ ) between 110 and 130 K, *J. Chem. Thermodyn.* 14, No. 7, 603-612 (1982).

Key words: excess volumes; experimental; liquefied natural gas; magnetic suspension densimeter; multicomponent mixtures; orthobaric liquid densities; tables; vapor pressures.



A magnetic suspension densimeter has been used to measure the orthobaric-liquid densities of 17 multicomponent mixtures of the major components of liquefied natural gas (LNG) at temperatures from 110 to 130 K. These mixtures ranged from a ternary mixture containing nitrogen, methane, and butane to 4-to-8-component methane-rich (74 to 90 moles percent) mixtures containing up to 5 moles percent of nitrogen, 16 moles percent of ethane, 7 moles percent of propane, 5 moles percent of the butanes, and 0.44 mole percent of the pentanes. Some of the compositions were selected to simulate commercial LNG mixtures. Results of vapor-pressure measurements are also presented. The major purpose of this work was to obtain multicomponent-mixture values that could be used to test mathematical models that have been developed for the prediction of LNG densities. To demonstrate the consistency of the multicomponent-mixture values, comparisons are presented between experimental densities and calculated values from an extended corresponding-states method that was optimized to pure-fluid and binary-mixture results from the LNG density project here. The total uncertainty of a single density measurement is estimated to be approximately 0.1 percent, which includes an allowance of three times the standard deviation for random error. The imprecision of measurement is a few parts in  $10^4$ .

**21432.** Gomberg, A.; Hall, J. R., Jr. Space heater—Rural death link, *Fire Service Today* 49, No. 9, 18-21 (Sept. 1982).

Key words: death rate; fire fatalities; heating equipment; rural; solid fuel.

The results of an analysis of fire causal factors in over 1600 fire fatalities are presented. Emphasis in this article is placed on the contribution of area heating equipment to a disproportionately high rural fire fatality rate. The role of solid fueled heating equipment is also discussed.

**21433.** Moody, J. R. The sampling, handling and storage of materials for trace analysis, *Philos. Trans. R. Soc. London Ser. A* 305, 669-680 (1982).

Key words: containers; contamination; pure reagents; sampling; trace analysis.

Trace and ultra-trace analyses require the most extreme care from the analyst. Too often this care is reflected in an inordinate amount of attention to the instrumentation and a corresponding inattention to sampling, sample stability, sample storage, and chemistry before analysis. For many elements, the control of contamination or sample stabilization, or both, may become the limiting factors in the accuracy of an analysis.

Numerous sample handling problems in trace element analysis are described and suggestions are made for the control of these problems. Analogous arguments can be made for similar problems in trace organic analysis. Examples of successful methods of sample handling are taken from relevant research results at the National Bureau of Standards.

**21434.** Barnes, I. L.; Murphy, T. J.; Michiels, E. A. I. Certification of lead concentration in Standard Reference Materials by isotope dilution mass spectrometry, *J. Assoc. Off. Anal. Chem.* 65, No. 4, 953-956 (1982).

Key words: analysis; isotope dilution mass spectrometry; lead; lead in foods; standard reference materials.

In response to needs for analytical standards by researchers studying the exposure of humans to lead, a wide variety of environmental and "food" Standard Reference Materials have been prepared and certified for lead as well as for many other elements. Among the food types are SRM 1571, Orchard Leaves, 45 ppm; SRM 1575, Pine Needles, 10.8 ppm; SRM 1573, Tomato Leaves, 6.3 ppm; SRM 1566, Oyster Tissue, 0.48 ppm; SRM 1577, Bovine Liver, 0.34 ppm; SRM 1568, Rice Flour, 0.045 ppm; and SRM 1567, Wheat Flour, 0.020 ppm. These materials, intended for use in calibrating instruments and methods, have been certified by a definitive method, isotope dilution mass spectrometry. The advantages and disadvantages of this technique are discussed and some suggestions for the use of its isotopic selectivity in the study of lead in the human environment are presented.

**21435.** Rosenstock, H. M.; Dannacher, J.; Liebman, J. F. The role of

excited electronic states in ion fragmentation:  $C_6H_6^+$ , *Radiat. Phys. Chem.* 20, No. 1, 7-28 (1982).

Key words: energetics; fluorescence; fragmentation; internal conversion; ions.

The present article presents a critical review of our understanding of the fragmentation behavior of the electronically excited  $C_6H_6^+$  system. This system produces a number of primary ionic fragments at low excitation energy. The determination of the structure of these fragments is discussed. The evidence for structural isomerization is reviewed, both for fragmenting and nonfragmenting  $C_6H_6^+$  ions. The energetics of various ionization and fragmentation processes is established and presented, leading to conclusions about the relative stability of various  $C_6H_6^+$  isomer states. The competition between fragmentation, internal conversion, and reradiation of electronic excitation energy is examined. Lastly, the methodology for estimating heats of formation of molecules and ions of unusual structure is briefly discussed.

**21436.** Agarwal, G. S.; Jha, S. S. Surface-enhanced second-harmonic generation at a metallic grating, *Phys. Rev. B* 26, No. 2, 482-496 (July 15, 1982).

Key words: second harmonic generation; surface enhanced optical phenomena.

The theory of surface-enhanced second-harmonic generation at a metallic grating is developed. Using the form of the nonlinear source polarization given by Bloembergen *et al.* [*Phys. Rev.* 174, 813 (1968)], we solve Maxwell's equations to obtain the fields at the second-harmonic frequency. The calculations are done up to second order in the surface-roughness parameter. These perturbation expressions are used to evaluate numerically the second-harmonic intensity, in various directions, produced by a plane wave incident on a metallic grating. The resonant enhancement in the second-harmonic intensity due to surface-plasmon excitation at fundamental frequency  $\omega$  is discussed and the results compared with some recent experimental observations. The second-harmonic fields are also shown to get enhancement due to excitation of surface plasmons at  $2\omega$ ; these, however, correspond to local-field enhancements at  $2\omega$  and are evanescent in nature.

**21437.** Plumb, H. H.  $^4\text{He}$  second and third virial coefficients from acoustical isotherms: The Helmholtz-Kirchhoff correction at temperatures below 35 K, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 77-88 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: acoustical thermometry; Helmholtz-Kirchhoff correction; low temperature thermometry; second  $^4\text{He}$  virial coefficient; third  $^4\text{He}$  virial coefficient.

Measurements of acoustical isotherms from 9 to 34 K have been extended up to 200,000 Pa and hence yield more accurate isotherm analyses because a determination of the quadratic pressure term permits a more accurate determination of the linear pressure term. The isotherm analysis has produced values for the  $^4\text{He}$  second and third virial coefficients: They are, respectively,  $B = 16.8925 - 383.095/T - 150.665/T^2$  ( $\text{cm}^3/\text{mol}$ ) and  $C = 5788/T$   $\text{cm}^6/\text{mol}^2$ . The isotherm slopes (linear term in pressure) that have been measured experimentally are compared with those that have been calculated from values of the second  $^4\text{He}$  virial coefficient,  $B(T)$ , which were determined in other, non-acoustical experiments. The close equality of these slope values indicates the inadequacy of the generally accepted "Helmholtz-Kirchhoff correction" (its theoretical derivation and/or its application to experimental measurements). The correction is usually involved to correct speed of sound measurement data in a confined tube to values that would have been measured in a free or open gas.

**21438.** Marshak, H. Nuclear orientation thermometry from  $\sim 0.001$  to  $\sim 1.2$  K, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 95-101 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).



**Key words:** absolute temperatures; Boltzmann factor; low temperatures; nuclear orientation thermometry;  $^3\text{He}/^4\text{He}$  dilution refrigerator;  $^{60}\text{CoCo}$  single crystal;  $^{166}\text{mHoHo}$  single crystal.

We have investigated  $\gamma$ -ray anisotropy thermometry using both  $^{60}\text{Co}$  in cobalt single crystals ( $^{60}\text{CoCo}$ ) and  $^{166}\text{mHo}$  in Ho single crystals ( $^{166}\text{mHoHo}$ ) for their potential use in defining a low temperature scale covering the range from  $\sim 0.001$  to  $\sim 1.2$  K. The values of temperature derived from nuclear orientation thermometers are thermodynamic since they are deduced from the Boltzmann factor; viz.  $\exp(-E_m/kT)$ . The accuracy of the thermodynamic temperatures obtained depends upon how well one knows  $E_m$  and the uncertainties (both statistical and systematic) of the measurement. In the case of  $^{60}\text{CoCo}$ ,  $E_m$  is known from NMR/ON (Nuclear Magnetic Resonance/Oriented Nuclei) measurements with an uncertainty of less than  $1/1000$ . In the temperature range of  $0.01$  to  $0.05$  K we have compared the  $^{60}\text{CoCo}$  thermometer to a Josephson junction noise thermometer, which also measures thermodynamic temperatures, and they agree within  $0.5\%$ . In the case of the  $^{166}\text{mHoHo}$  thermometer, which covers the temperature region of  $\sim 32$  mK to  $\sim 1.2$  K,  $E_m$  has not been measured by NMR/ON and thus for the present it must be considered to be a secondary thermometer (e.g., as the susceptibility of the paramagnetic salt cerium magnesium nitrate).

**21439.** Pfeiffer, E. R.; Kaeser, R. S. Realization of the 1976 provisional 0.5 K to 30 K temperature scale at the National Bureau of Standards, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 159-167 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

**Key words:** calibration methods; EPT-76; low temperature; superconducting fixed points; temperature scales.

The National Bureau of Standards presently disseminates a version of the "1976 Provisional 0.5 K to 30 K Temperature Scale" (EPT-76) which is maintained on two rhodium-iron resistance thermometers. Calibrations on the EPT-76 are made using a minicomputer-controlled measurement system. Maintenance of the scale is periodically checked against realization of the superconducting transition points of NBS SRM 767 (which comprise 5 of the 11 defining reference points of the EPT-76). In addition, versions of the EPT-76 derived from the NBS 2-20 K Scale (maintained on germanium resistance thermometers) and from the NBS version of the IPTS-68 (maintained on platinum resistance thermometers) have been realized and compared with the rhodium-iron based version over their respective overlapping regions. From those checks and comparisons, and from similar data from other sources, it is concluded that the EPT-76 is non-unique by as much as  $1$  mK at several places over its  $0.5$  to  $30$  K range. Thus, an uncertainty of  $\pm 1$  mK has been assigned to the EPT-76 calibrations disseminated by NBS. These are tolerable limits considering the provisional status of the scale.

**21440.** Furukawa, G. T. Reproducibility of the triple point of argon in sealed transportable cells, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 239-248 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

**Key words:** argon triple point; calibration methods; fixed points; platinum resistance thermometer, capsule-type; sealed cells, argon.

The reproducibility of the triple point of argon sealed in miniature pressure cells was investigated in calorimetric apparatus. The results obtained with samples of 99.9999 percent purity sealed in three cells of different designs, using two calorimetric cryostats, show that the triple point of argon can be reproduced well within  $\pm 0.1$  mK. Measurements with six thermometers demonstrate that calibrations can be obtained consistent within the reproducibility of the fixed point.

**21441.** Schooley, J. F.; Soulen, R. J., Jr. Superconductive thermometric fixed points, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982) Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 251-260 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

**Key words:** SRMs; superconductive transition temperatures; superconductivity; temperature fixed points; temperature scales; thermometry.

We review the progress since the 5th Temperature Symposium in the development of temperature reference points based upon the transitions of various metal samples between the normal and superconductive states. Two superconductive fixed point devices, known as SRM (Standard Reference Material) 767 and 768, have become available from the National Bureau of Standards. One of these devices provides five of the temperature reference points for the 1976 Provisional 0.5 K to 30 K Temperature Scale; the other provides the mechanism for transmitting an NBS cryogenic temperature scale covering the range  $0.01$  K to  $0.5$  K. Current efforts in superconductive fixed-point research are devoted to evaluating superconductive transitions as possible reference temperatures for a replacement scale to succeed the IPTS-68.

**21442.** Furukawa, G. T.; Bigge, W. R. Reproducibility of some triple point of water cells, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 291-297 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

**Key words:** calibration at water triple point; fixed points; platinum resistance thermometer; triple point; triple point of water; water cell.

The reproducibility of some triple point of water cells was investigated by platinum resistance thermometry. The standard deviation of measurements with a single cell was found to be better than  $\pm 0.01$  mK. The range of temperatures observed with different cells was about  $0.2$  mK. The cells with more residual air tended to give lower temperatures. The cells of high quality gave temperatures within the range  $0.05$  mK.

**21443.** Figueroa, J. M.; Mangum, B. W. The triple point of rubidium: A temperature fixed point for biomedical applications, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 327-337 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

**Key words:** biomedical temperature fixed point; melting point of Rb; Rb; temperature fixed point; temperature reference point; triple point of Rb.

In order to test the feasibility of using the triple point of rubidium as a thermometric fixed point in biomedical applications, a study of the melting and freezing behavior of this metal was conducted. An investigation of the reproducibility of the plateau temperatures of a group of six rubidium cells, filled under vacuum, was made. The triple-point temperature of pure rubidium was estimated by fitting the experimental data to a hyperbolic equation under the hypothesis of the theory of dilute solutions. The triple-point temperature was established to be  $39.265 \pm 0.014^\circ\text{C}$ , at the  $99.7\%$  confidence interval.

**21444.** Furukawa, G. T.; Pfeiffer, E. R. Investigation of the freezing temperature of cadmium, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, V, 355-360 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

**Key words:** cadmium freezing temperature; fixed points, cadmium; freezing points, cadmium.

The freezing points of five cadmium cells, which were prepared using samples from two different sources, were found to agree within  $\pm 0.1$  m°C. The calibration, during a single freeze, of six standard platinum resistance thermometers (SPRT's) at temperatures all within  $\pm 0.1$  m°C is demonstrated. Measurements with eight SPRT's gave an average freezing-point temperature of  $321.1082^\circ\text{C}$ . The results show that the cadmium point is suitable for testing the consistency of calibration of SPRT's on the International Practical Temperature Scale of 1968 and that it is also a suitable alternative to the zinc point for calibrating SPRT's that are used below  $321^\circ\text{C}$ .



**21445.** Cutkosky, R. D. Automatic resistance thermometer bridges for new and special applications, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 711-713 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: automatic bridge; bridges; resistance thermometry.

Extensive field tests of several automatic resistance thermometer bridges constructed along the lines described in a recent paper have demonstrated the practicality and versatility of the design. Two new versions of the original instrument are now available. In one of these, the resistance range has been extended to over 100 ohms, and in the other, the lowest available measuring current has been reduced to 1/8 mA. Some critical aspects of the design and construction of these instruments are described.

**21446.** Evans, J. P. Experiences with high-temperature platinum resistance thermometers, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 771-781 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: bifilar helix; electrical guard; freezing point cells; gold point; high temperature; insulation resistance; platinum resistance thermometer; stability; temperature scale; thermometer characteristics.

As part of an effort to develop high-temperature platinum resistance thermometers suitable for use as defining instruments to the gold point on a practical temperature scale, we have built and tested thermometers with nominal resistance at 0°C of 2.5 ohms. The thermometers are made with silica-glass insulating parts and protecting sheaths. Resistors of the single-layer, bifilar-helix design and of other designs have been employed, and a guarded lead structure has been developed. The thermometers have proven to be satisfactory in some respects but deficient in others, when exposed to 1100°C for long periods of time. The stability and other characteristics of the thermometers, and the behavior of the thermometers in thermometric fixed-point cells, are discussed.

**21447.** Mangum, B. W.; Evans, G. A., Jr. Investigation of the stability of small platinum resistance thermometers, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 795-799 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: platinum resistance thermometers; PRT; resistance thermometers; RTD; temperature sensors; thermometry.

We have investigated the stability of a selection of small platinum resistance thermometers (RTDs) upon thermal cycling and handling. Sixty thermometers obtained from five manufacturers were studied. Several models or types were included in the investigation. Comparisons are made of the differences in the stability of the products from the different companies. Most of the RTDs investigated exhibited calibration drifts and also effects due to the presence of moisture. For the thermometers investigated, there was no improvement in the stability if the resistance ratio,  $R(t)/R_0 = W(t)$  were used as the criterion instead of the resistance itself. Fifty percent of the RTDs underwent changes  $[(\Delta R_0/R_0)10^2]$  in  $R_0$  greater than the equivalent of 0.015°C; twenty-five percent had changes greater than the equivalent of 0.05°C. It appears, nevertheless, to be possible to select RTDs which are stable upon thermal cycling, but the presence of moisture is definitely a problem if it is desired to use RTDs for precision thermometry.

**21448.** Burns, G. W. The nicrosil versus nilsil thermocouple: Recent developments and present status, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 1121-1127 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: base-metal thermocouples; nickel-chromium-silicon alloys; nickel-silicon alloys; nicrosil/nilsil thermocouples; thermocouple emf-drift; thermocouple standardization; Type K thermocouples.

Some new nickel-base thermocouple alloys called nicrosil and nilsil were described by Burley, of the Materials Research Laboratories (MRL, Australia), at the 5th Symposium on Temperature in 1971. Since 1971, these thermocouple alloys have undergone further development, and their properties and performance have been the subject of considerable study at various government and private laboratories around the world. The studies conducted on the thermocouple alloys since 1971 are reviewed, and the present status of the use, availability, and standardization of the nicrosil/nilsil thermocouple in the United States is discussed.

**21449.** Van Degriift, C. T.; Kaeser, R. S. Automation of measurements in a low temperature laboratory, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 1299-1305 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: measurement automation; measurement system; temperature; temperature control.

The general software and hardware architecture and performance of a versatile automatic low temperature laboratory control and calibration system is described. The system has been used for measurement of  $P(T,V,H)$  on solid He-3 in one laboratory and for the intercomparison of superconductive fixed points and germanium, rhodium-iron, and platinum thermometers in another. Temperature measurements can be performed with an accuracy which meets the needs of a primary standards laboratory. Magnetic field measurements made with a cryogenic Hall probe have a resolution of 18  $\mu$ T at a field of 8 T. Several tunnel diode oscillators sensing pressure, dielectric constant, magnetic susceptibility or temperature can be tracked and monitored with better than 0.001 ppm frequency resolution. Provisions are made for the scheduling of complex combinations of measurements including the control of multiple heaters in a sweeping or stepwise manner. A companion program performs preliminary data analysis doing the necessary time interpolation and system calibration.

**21450.** Biolsi, L.; Rainwater, J. C.; Holland, P. M. Transport properties of monatomic carbon, *J. Chem. Phys.* 77, No. 1, 448-454 (July 1, 1982).

Key words: ablation; carbon gas; Hulburt-Hirschfelder potential; planetary entry; spectroscopic parameters; transport properties.

Transport properties of monatomic gases depend on the two-body atom-atom interaction potential. When two ground state carbon atoms interact, they can follow any of 18 potential energy curves corresponding to the  $C_2$  molecule. Accurate representations of these curves have been obtained for each of the 18 states and transport collision integrals have been calculated for each state. Those states with an attractive minimum in the potential have been represented by the Hulburt-Hirschfelder potential and the purely repulsive states have been represented by the exponential repulsive potential. The collision integrals are compared with results obtained in previous studies. The effects of the details of the potential on the resulting transport collision integrals are discussed.

**21451.** Eckerle, K. L.; Hsia, J. J. Proposed standards for the NBS retroreflection MAP, *Color* 7, No. 3, 235-241 (1982).

Key words: coefficient of luminous intensity (C.I.L.); filters; luminous transmittance; retroreflectance; retroreflector; spectral transmittance.

A proposed Measurement Assurance Program (MAP) service for retroreflectance is under development at the National Bureau of Standards. A package for the MAP consists of high- and low-intensity bead-sheeting retroreflectors, a prismatic retroreflector, and seven colored glass filters. The retroreflectors are being measured using the NBS reference retroreflectometer. The glass filter measurements are based on spectral data obtained using a high-accuracy reference spectrophotometer. The luminous transmittances are calculated from the spectral transmittances using CIE Illuminant A and CIE  $V(\lambda)$ -type



detector, and can be used to check the combined spectral distribution of source and reponsivity of the receiver. Computations are mentioned which show that if a color-correction filter is not chosen carefully, large errors may result. Preliminary results for pressure and temperature effects on two types of retroreflectors indicate small changes. Temperatures used were nominally 15, 25, and 32°C. Pressures used were nominally 0.85, 1.0, and 1.25 bars. Results showing the sensitivity of the coefficient of luminous intensity (C.I.L.) of the retroreflectors to various geometrical parameters are described. These parameters include the observation angle  $\alpha$ , the entrance angles  $\beta_1$  and  $\beta_2$ , the source and receiver apertures  $\delta$ , and the rotation angle  $\epsilon$ .

- 21452.** Kirklin, D. R.; Domalski, E. S.; Kelly, R. V.; Robbins, C. R. Ash content and x-ray analysis of selected RDF and coal samples as a function of temperature, *Res. Conserv.* 9, 243-257 (1982).

Key words: ash content; coal ash; RDF ash; refuse-derived fuel; x-ray analysis.

The objectives of the study were to find out whether recommended ashing procedures which are to be used in proposed ASTM protocols for a particular form of refuse-derived fuel (RDF-3) or which are used in existing ASTM protocols for coal yield different ash content values at different temperatures and to select the optimum ashing temperature for RDF-3.

The ash content was determined for three selected refuse-derived fuel (RDF) and four coal samples at 100°C intervals over the temperature range from 475° to 1175°C. X-ray diffraction analysis of these ash samples reveals sequential changes in the crystalline phases, suggesting which chemical reactions may be taking place at the various temperatures. The mineral phases present at a given temperature were remarkably similar for all RDF ashes. This is also true for the coal ash samples, although to a lesser extent.

From this study it is concluded that 725°C should be recommended as the standard ashing temperature for RDF because of the close agreement between values obtained at 675°C and 775°C, the small uncertainties associated with measurements at these temperatures, finely divided metals are primarily in the unoxidized state, and carbonate decomposition is complete. The study also pointed out the inability to select equivalent analysis samples of RDF.

- 21453.** Guttman, C. M.; McCrackin, F. L.; Han, C. C. Monte Carlo calculation of the hydrodynamic radius at the  $\Theta$  point. Deviations from analytical Gaussian behavior, *Macromolecules*, pp. 1205-1207 (July-Aug. 1982).

Key words: chain simulation; hydrodynamic radius; Monte Carlo; polymers; polystyrene; theta chain.

The hydrodynamic radius of polymers is computed using Kirkwood's formula for polymer chains at the theta point created by Monte Carlo simulation in which both volume exclusion and the energetics of nearest neighbor interactions are taken into account. The product,  $\rho$ , of the radius of gyration,  $\langle S^2 \rangle^{1/2}$  and  $\langle 1/R_H \rangle$ , is found for these chains to differ from that value of  $\rho$  found for the analytical Gaussian coil. The deviation of the Monte Carlo obtain  $\rho$  is in the same direction as the experimentally observed deviation of  $\rho$  from the analytical Gaussian result. New experimental values of  $1/R_H$  and  $\rho$  are also given.

- 21454.** Guildner, L. A.; Edsinger, R. E. Progress in NBS gas thermometry above 500°C, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 43-48 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: constant volume gas thermometry; high temperature platinum resistance thermometers; high temperature thermostat; thermal expansion; thermodynamic temperature; thermomolecular pressure; virial coefficients.

Measurement of thermodynamic temperatures by gas thermometry above 500°C requires the use of different apparatus than for lower temperatures. Extensive tests have been made of the thermostats and high temperature platinum resistance thermometers. Techniques to reduce the presence of hydrogen, caused by diffusion through the metals, have been established. After more than one thousand hours of operation at 962°C, the thermostat was redesigned and rebuilt to

improve its performance. Thermal expansion measurements of the bulb material by an interferometric technique are being carried out in a second thermostat designed to operate up to the gold point. Gas thermometer measurements have been made at low pressures over a considerable range of temperature, but especially at 660°C to evaluate the attainable precision. Finally, a new gas thermometer has been built with a modified suspension system to improve temperature uniformity of the bulb. The measurement at an upper temperature limit of 1337 K (the freezing point of gold) remains the final goal of this project.

- 21455.** Maki, A. G.; Lovas, F. J. Infrared diode laser spectra of the  $\Delta v=1$  band of AlF and the  $\Delta v=2$  band of KF, *J. Mol. Spectrosc.* 95, 80-91 (1982).

Key words: aluminum monofluoride; diatomic; infrared; light temperature spectra; potassium fluoride; potential function; spectra.

High-resolution diode laser spectra of AlF and of KF were measured between 827 and 855  $\text{cm}^{-1}$ . Measurements were made on the  $v=1-0$ , 2-1, and 3-2 transitions of AlF at temperatures between 1000 and 1190 K. The band centers were determined to be at  $792.6882 \pm 0.0004 \text{ cm}^{-1}$ ,  $783.1633 \pm 0.0004 \text{ cm}^{-1}$ , and  $773.7534 \pm 0.0007 \text{ cm}^{-1}$ , respectively. For KF, temperatures between 1150 and 1250 K were used to measure the  $v=2-0$ , 3-1, and 4-2 transitions for which the band centers were determined to be at  $837.9702 \pm 0.0003 \text{ cm}^{-1}$ ,  $828.3966 \pm 0.0003 \text{ cm}^{-1}$ , and  $818.9350 \pm 0.0005 \text{ cm}^{-1}$ , respectively. These infrared measurements were combined with microwave measurements, reported by others, to obtain new Dunham constants for AlF and for KF. The values for  $\omega_e$ ,  $B_e$ , and the Dunham  $a_i$  potential constants were obtained directly from the observed transitions by means of a nonlinear least-squares analysis.

- 21456.** Gramlich, J. W.; Machlan, L. A.; Brletic, K. A.; Kelly, W. R. Thermal-ionization isotope-dilution mass spectrometry as a definitive method for determination of potassium in serum, *Clin. Chem.* 28, No. 6, 1309-1313 (1982).

Key words: definitive method; isotopic analysis; mass spectrometry; potassium; serum.

Thermal-ionization isotope-dilution mass spectrometry is a highly precise and accurate method for the determination of potassium concentrations in serum. Although not suited for routine use because of the time and expense required, the technique provides an extremely valuable tool for the characterization of reference materials and for evaluating other analytical methods. The technique has recently been used to determine the concentration of potassium in a human serum standard, NBS Standard Reference Material 909. Seven vials of the serum were chemically processed and then analyzed by two spectroscopists independently, using different mass spectrometers. The results confirm previous work that indicates that a precision of 0.1% relative can be routinely achieved. The systematic errors in the method have been thoroughly evaluated. When the precise results are thus corrected, they are essentially bias free and hence definitive.

- 21457.** Krause, R. F., Jr.; Kukacka, L. E. Durability of various cements in a well of the Cerro Prieto geothermal field, *Proc. Geothermal Engineering and Materials (GEM) Program Conf., Sheraton Airport Inn, San Diego, CA, Oct. 6-8, 1982*, pp. 97-105 (U.S. Department of Energy, Geothermal Energy Division, 1333 Broadway Street, Oakland, CA 94612, 1982).

Key words: Cerro Prieto field; compressive strength; geothermal-well cements; water permeability.

The durability of each of 16 different cements was evaluated by both room temperature compressive strength and water permeability measurements, following various periods of treatment of the cements in flowing geothermal fluid of the Cerro Prieto field of Mexico. Some of these cements were selected through a Department of Energy program to develop improved cements for geothermal well completion while the others were contributed by several other institutions interested in the tests. Two types of specimens of the cements were used in the tests: (a) 50 mm cubes which were precured 1 da in molds under water in an autoclave at 200°C and 20 MPa and (b) cement slurries which were prepared and cast in sandstone cups at the field. Through the cooperation of the Comision Federal de Electricidad a set of both types of specimens was installed in baskets



which were placed 700 m downhole a well at 214°C, and an identical set of specimens was installed in special aboveground vessels near the wellhead. Following periods of 1 da, 3 mo, 6 mo, and 12 mo, specimens were withdrawn from the geothermal treatment and divided evenly between the Instituto de Investigaciones Electricas and the National Bureau of Standards for property measurements. This paper gives the downhole results by the latter laboratory. Final values will be published when the results of both laboratories are collated and reviewed.

**21458.** Alvarez, R. *Citrus Leaves (SRM 1572)—A new NBS plant tissue Standard Reference Material certified for trace element concentrations*, (Proc. Ninth Int. Plant Nutrition Colloq., Warwick University, England, Aug. 22-27, 1982), Paper in *Plant Nutrition 1982*, A. Scaife, ed., 1, 22-26 (Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Slough SL2 3BN, UK, 1982).

Key words: analysis; certified reference materials; chemical composition; elemental; foliar analysis; nutrition; plants; standard reference materials.

Accurate values for nutrient and potentially toxic trace elements in plant tissues are necessary to formulate valid conclusions regarding the effects of these elements on plant growth and stress. Although several analytical methods are usually available for these analytical determinations, the results obtained are not always accurate. One approach towards validating methodology and experimental results is through the use of certified reference materials such as those issued by the U.S. National Bureau of Standards as Standard Reference Materials (SRM's). A number of SRM's have been developed for use in plant tissue and agricultural food product analysis. They are: Spinach, SRM 1570; Orchard Leaves, SRM 1571; Tomato Leaves, SRM 1573; Pine Needles, SRM 1575; Wheat Flour, SRM 1567; and Rice Flour, SRM 1568. The spinach material is no longer available and after ten years, the supply of the orchard leaves SRM has been almost exhausted. Citrus Leaves, SRM 1572, is intended as a replacement for the latter. The Certificate of Analysis for each SRM contains such information as the homogeneity of the powdered material, the minimum sample size to be used, and the certified values for the elements with their uncertainties. A certified value is based either on the concordant results by two or more independent analytical methods or on results by a definitive method, i.e., an accurate method having identified systematic errors. These certified values can serve as common reference points for comparison of data acquired over a long period by various investigators using a variety of methods.

**21459.** Goldfarb, R. B.; Rao, K. V.; Chen, H. S.; Patton, C. E. *Further evidence for a spin-glass phase transition in amorphous Fe-Mn-P-B-Al alloys*, *J. Appl. Phys.* **53**, No. 3, 2217-2219 (Mar. 1982).

Key words: hysteresis; magnetic phase transition; magnetic susceptibility; micromagnetism; spin glass; thermoremanent magnetization.

Low field dc susceptibility, thermoremanent magnetization, and hysteresis studies are presented for two amorphous Fe-Mn-P-B-Al alloys of concentrations close to, and on either side of, the multicritical point in the magnetic phase diagram. They exhibit spin-glass, and para-ferro-spin-glass transitions, respectively. For the spin-glass alloy, the Edwards-Anderson-type order parameter deduced from the dc susceptibility is found to yield a mean-field-valued critical exponent. In the alloy with two magnetic transitions, the temperature dependence of the thermoremanence and hysteresis indicate a ferro-spin-glass transition temperature consistent with that deduced from a scaling approach for the same alloy system.

**21460.** Johnson, R. G.; Bowman, C. D. *High resolution powder diffraction by white source transmission measurements*, (Proc. IPNS Symp. Neutron Scattering, Argonne, IL, Aug. 12-14, 1981), *AIP Conf. No. 89*, pp. 53-55 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: condensed matter study; high resolution; iron; neutron powder diffraction; total neutron cross section; transmission geometry.

Neutron powder diffraction has been studied by measuring the total

neutron cross section using neutron time-of-flight in transmission geometry. This method is equivalent to measurements in scattering geometry of powder diffraction at  $2\theta=180^\circ$ . Measurements on iron samples were conducted using the NBS 100 MeV electron linac as a pulsed neutron source and using flight paths of 20 and 60 meters. The resolution at 60 m for 25-meV neutrons was limited to  $d\lambda/\lambda=0.2\%$  primarily by moderator hold-up. Although the change in cross section at the Bragg edges may be quite small, counting rates are high permitting the recording of data with a 0.1% statistical precision in about one day. For the Fe samples, diffraction edges were distinguished as high as  $n=196$  (where  $n$  is the sum of the squares of the Miller indices) with all edges distinguishable below  $n=90$ .

**21461.** Bowman, C. D.; Johnson, R. G. *Measurements of inelastic scattering of eV neutrons*, (Proc. IPNS Symp. Neutron Scattering, Argonne, IL, Aug. 12-14, 1981), *AIP Conf. No. 89*, pp. 84-86 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: eV neutrons; inelastic scattering; molecular vibration; momentum transfer; neutron detection; time-of-flight.

A technique has been demonstrated for studying the inelastic scattering of eV neutrons using a pulsed white source. Measurements have been completed on benzene for incident energies in the range 1.5 to 15 eV and for  $q$  values from 13 to 120  $\text{\AA}^{-1}$ . Details of the method and possibilities for improvement and extension are presented.

**21462.** Estin, A. J.; Daywitt, W. C. *Evaluation of signal-plus-noise detection error in an envelope detector with logarithmic compression*, *IEEE Trans. Inf. Theory* **27**, No. 5, 663-664 (Sept. 1981).

Key words: detection; detection amplitude error; noisy signal detection; satellite communication measurements.

A correction factor is derived for the amplitude of the detected output of a modulated sinusoidal signal with added Gaussian noise, as processed by an envelope detector with logarithmic compression. Supporting experimental data are presented that were obtained using a typical system having such a detector.

**21463.** Netzer, F. P.; Madey, T. E. *Interaction of  $\text{NH}_3$  with oxygen-predosed Ni(111)*, *Surf. Sci.* **119**, 422-432 (1982).

Key words: ammonia; chemisorption; electron stimulated desorption; short range order; surface structure.

We have used ESDIAD (electron stimulated desorption ion angular distributions), LEED and thermal desorption to study the structure and kinetics of  $\text{NH}_3$  interacting with preadsorbed oxygen on a Ni(111) surface. We find evidence for a striking effect: Traces of preadsorbed oxygen will induce a high degree of azimuthal ordering in a fractional monolayer of adsorbed  $\text{NH}_3$  molecules; the H ligands are oriented azimuthally in the  $[1\bar{1}2]$  directions. In contrast, adsorption of  $\text{NH}_3$  on a clean Ni(111) surface results in random azimuthal orientation of the  $\text{NH}_3$  molecules, which are bound to the metal via the N atom with H pointing away from the surface. Even for very low oxygen coverages,  $\theta_{\text{O}} \sim 0.05$  (annealed layer), the majority of  $\text{NH}_3$  is azimuthally oriented, so that one O atom influences more than one  $\text{NH}_3$  molecule. LEED reveals that long range order is absent in the composite  $\text{NH}_3+\text{O}$  overlayer. Thermal desorption reveals that the presence of O leads to an increase in  $\text{NH}_3$  desorption energy. We postulate that the  $\text{NH}_3$  interacts with atomic O via a hydrogen bond, leading to *local azimuthal ordering in the absence of long range order*.

**21464.** Dehl, R. E. *On the characterization of porosity in PTFE-carbon composite implant materials by mercury porosimetry*, *J. Biomed. Mater. Res.* **16**, 715-719 (1982).

Key words: mercury porosimetry; pore size; pore volume; porous implant materials; PTFE-carbon composite.

Questions have been raised about the use of mercury intrusion porosimetry to measure interconnecting pore sizes and void volumes in relatively soft and flexible materials such as porous implant composites of PTFE and carbon fibers. We have studied the effect of precompression of one such commercial composite on the mercury intrusion curves which cover all pore diameters greater than about 16  $\mu\text{m}$ , the range of interest for tissue ingrowth applications. Prior compression by a pressure 20% greater than that encountered by the



material during a mercury intrusion experiment did not change the ensuing pore size distribution curve, as compared with a noncompressed sample. Deformation of the material at higher pressures sufficient to decrease the sample volume inelastically by 17, 33, and 67% changed the shape of the mercury intrusion curves significantly, indicating that this technique can be used to detect prior deformation of an "unknown" sample. In the undeformed material, less than 15% of the total void as measured by mercury porosimetry consists of interconnecting pores  $>100\text{ }\mu\text{m}$  in diameter and more than 50% of the void volume is composed of pores  $<40\text{ }\mu\text{m}$  in diameter.

- 21465.** McKinney, J. E.; Wu, W. Relationship between subsurface damage and wear of dental restorative composites, *J. Dent. Res.* **61**, No. 9, 1083-1088 (Sept. 1982).

Key words: composite; dental; fatigue; microdefect; pin and disc; wear.

Pin and disc wear measurements were made on a commercial dental composite over a stress range from 2.5 to 20 MPa. The wear rates were found to increase suddenly during wear at times which tended to decrease with increasing stress. The results are interpreted in terms of wear mode conversion which results from the build-up of subsurface damage during wear. Micrographs showing damaged layers are compared with those from restorations worn *in vivo*.

- 21466.** Schwartz, R. B.; Eisenhauer, C. M. Use of a  $\text{D}_2\text{O}$  moderated  $\text{Cf-252}$  source for dosimeter testing and calibrating, *Proc. 8th DoE Workshop Personnel Neutron Dosimetry*, Louisville, KY, June 18-19, 1981, pp. 153-162 (Battelle, Pacific Northwest Laboratory, Richland, WA 99352, 1981).

Key words: albedo dosimeter; Californium 252; dose equivalent; moderated californium; neutron personnel dosimeter; remmeter.

The 15 cm radius  $\text{D}_2\text{O}$  moderated  $^{252}\text{Cf}$  source has been used to test and calibrate several types of neutron personnel dosimeters and remmeters. Measurements were made of the response of the devices to the moderated neutrons, relative to the response from a bare  $^{252}\text{Cf}$  source. In general, the measured results are in good agreement with calculations, and dosimeters calibrated with the moderated source gave accurate results when used to measure the dose equivalent at power reactors.

- 21467.** Patterson, C. W.; McDowell, R. S.; Nereson, N. G.; Krohn, B. J.; Wells, J. S.; Petersen, F. R. Tunable laser diode study of the  $\nu_3$  band of  $\text{SiF}_4$  near  $9.7\text{ }\mu\text{m}$ , *J. Mol. Spectrosc.* **91**, 416-423 (1982).

Key words: high resolution spectroscopy; saturation spectroscopy;  $\text{SiF}_4$  spectroscopic constants; silicon tetrafluoride; symmetric top molecule; tunable diode laser.

Doppler-limited tunable-diode laser spectra of the stretching fundamental  $\nu_3$  of  $^{28}\text{SiF}_4$  near  $1031\text{ cm}^{-1}$  were analyzed and the spectroscopic constants determined. The  $\nu_3$  vibrational dipole moment derivative was determined for several rovibrational lines.

- 21468.** Eisenhauer, C. M.; Schwartz, R. B. Analysis of neutron room return, *Proc. 8th DoE Workshop Personnel Neutron Dosimetry*, Louisville, KY, June 18-19, 1981, pp. 171-180 (Battelle, Pacific Northwest Laboratory, Richland, WA 99352, 1981).

Key words: albedo dosimeter; calibration; Californium source; neutron dosimeter; rem-meter; room-return.

An approach for measuring the effect of neutrons scattered from the walls of a calibration room on the response of neutron personnel monitors is discussed. Experimental results are presented for 9-inch and 3-inch polyethylene spheres and for albedo dosimeters irradiated with a  $^{252}\text{Cf}$  neutron source. An analytical model for predicting the effects of scattered neutrons is reviewed and comparisons with experiments are made.

- 21469.** Hoer, C. A. A high-power dual six-port automatic network analyzer used in determining biological effects of RF and microwave radiation, *IEEE Trans. Microwave Theory Tech.* **MTT-29**, No. 12, 1356-1364 (Dec. 1981).

Key words: impedance; microwave radiation; network analyzer; power; reflection coefficient; scattering parameters; six-port.

The design, calibration, and performance of a high-power (1-1000 W) automatic network analyzer based on the six-port concept are described for the 10-100-MHz range. Calibration is performed with a length of transmission line as the only impedance standard needed. A 10-mW thermistor mount is the standard of power. Imprecision in measuring reflection coefficient  $\Gamma$  is 0.0001 in magnitude and  $0.005/|\Gamma|$  degrees in phase. Corresponding estimated systematic errors are 0.001 and  $0.1/|\Gamma|$  degrees. Imprecision in measuring power is 0.01 percent of range (20 W, 200 W, or 1000 W) with an estimated systematic error of 1.25 percent of reading.

- 21470.** Kirklin, D. R.; Colbert, J. C.; Decker, P. H.; Ledford, A. E.; Ryan, R. V.; Domalski, E. S. The variability of municipal solid waste and its relationship to the determination of the calorific value of refuse-derived fuels, *Res. Conserv.* **9**, 281-300 (1982).

Key words: ash content; bomb calorimetry; calorific value; heating value; MSW; municipal solid waste; RDF; refuse-derived fuel.

A study was carried out to examine the variability, over a two-week period, of municipal solid waste (MSW) at the Baltimore County Resource Recovery Facility in Cockeysville, Maryland. Samples of municipal solid waste which had been processed through a primary shredder were collected daily for two weeks. After the total moisture content was determined, the samples were reduced in particle size to 2mm or less. A total of 40 samples were prepared for measurements. Testing was carried out for residual moisture, furnace ash, bomb ash, and calorific or higher heating value.

The daily variability (i.e., excluding the within bag variability) of MSW is 36% and 37% for moisture and ash, respectively. The combustible fraction of MSW is directly related to the moisture and bomb-ash free higher heating value (HHV3-B) which has a daily variability (i.e., excluding the within bag variability) of only 4%. Statistical analysis of the data suggests that the day to day variability of MSW constitutes 70 to 80% of the overall variability, with the other variables being errors in sampling, size reduction procedures, and measurement techniques.

- 21471.** Kasen, M. B. Standardizing nonmetallic composite materials for cryogenic applications, *Proc. Nonmetallic Materials and Composites at Low Temperatures*, Geneva, Switzerland, Aug. 4-5, 1980, G. Hartwig and D. Evens, eds., **2**, 327-337 (Plenum Publ. Corp., 1982).

Key words: composites; cryogenics; laminates; material coding; materials standards; nonmetallic materials.

The need for standardized nonmetallic composite laminates in the cryogenic industry is reviewed. A description is provided of current efforts underway in the U.S. to meet the immediate cryogenic needs and for establishing the basis for an orderly materials development program to meet long range needs. The advantages of a comprehensive coded composite materials designation system is discussed and an example pertinent to the cryogenic industry is given.

- 21472.** Soulen, R. J., Jr.; Van Vechten, D.; Seppä, H. Effect of additive noise and bandpass filter on the performance of a Josephson junction noise thermometer, *Rev. Sci. Instrum.* **53**, No. 9, 1355-1362 (Sept. 1982).

Key words: filters; noise thermometry; variance; white noise.

A Josephson junction may be used to convert the voltage fluctuations generated by Johnson (i.e., thermal) noise in a resistor into frequency fluctuations. The variance of the frequency fluctuations is thus a measurement of the Johnson noise and, therefore, of the temperature. This particular type of noise thermometer has been used at the National Bureau of Standards as part of a program to define a cryogenic temperature scale. We have studied the detailed influence of two types of post-detection bandpass filters (square and one-pole Butterworth) on the measured variance. We report here on these measurements and the circuit model used to fit them. The conclusion is that small but well understood corrections must be applied to the measured variance whenever the measurement time (i.e., gate time) of the frequency becomes comparable with the response time (defined as the inverse of the bandwidth) of the bandpass filter.

- 21473.** Beehler, R. E. Time/frequency services of the U.S. National



Key words: satellites; time and frequency; time coordination; time dissemination.

The National Bureau of Standards (NBS) currently disseminates time and frequency information to a broad range of users by LF and HF radio broadcasts; a telephone time-of-day service; calibration of selected Loran-C, TV, and Omega Navigation System broadcasts; a time code from two geostationary meteorological satellites; and appropriate publications. These various services will be described briefly with special emphasis on the newer satellite dissemination method.

For the future, satellite-based dissemination and coordination methods appear to offer promise for substantial improvement relative to present terrestrial services and techniques. Some of the potential advantages include better coverage throughout the world, greater reliability of reception, higher accuracy and precision, economical operation, and reduced interference. Some of the leading satellite alternatives for future time/frequency dissemination and/or coordination will be discussed and evaluated.

In recognition of the potential improvements realizable from satellite-based techniques, Study Group 7 of the International CCIR organization has initiated a study of possibilities for developing operational use of such techniques for improved dissemination and coordination on a worldwide basis. A status report on this study will be given.

**21474.** Bowen, R. L.; Cobb, E. N.; Rapson, J. E. Adhesive bonding of various materials to hard tooth tissues: Improvement in bond strength to dentin, *J. Dent. Res.* 61, No. 9, 1070-1076 (Sept. 1982).

Key words: adhesion; bonding; cleanser; composites; coupling agent; dentin; mordant; polymer; resin.

Enhanced adhesive bonding of composite restorative materials can improve treatment of cervical erosions, root caries, and other conditions with minimal cutting of dentin. Materials and methods have been developed which increase the strengths of adhesive bonds to the dentin of extracted teeth. The strong bonds were obtained by the use of an aqueous ferric oxalate mordant solution followed in sequence by acetone solutions of two coupling agents. Evidence from scanning electron micrography suggests that the first treatment dissolves the disturbed surface layer and precipitates insoluble material in the openings of the dentinal tubules. The coupling agents apparently provide molecules which are bound to the surface and can polymerize with the resin of the composite material applied subsequently. The dentinal tubules are neither enlarged nor filled to any significant depth with the adhesive or polymeric materials. With the new process adhesive bond strengths to dentin have averaged over 11 MPa (1,600 psi) after storage in distilled water at room temperature for 1 to 10 days.

**21475.** Maximon, L. C. Integral representations for the regular and irregular s-wave Coulomb wave functions, *Department of Physics Technical Report, GWU/DP/TR-82/1*, 21 pages (George Washington University, Department of Physics, Washington, DC 20052, 1982).

Key words: bound state Coulomb wave functions; continuum wave functions; Coulomb amplitude; Coulomb wave functions; integral representations; Whittaker functions.

We derive a number of new integral representations for the bound and continuum s-wave Coulomb wave functions, written in terms of the Whittaker functions  $W_{\kappa,1/2}(2\beta r)$ ,  $M_{\kappa,1/2}(2\beta r)$ ,  $W_{-i\eta,1/2}(-2iqr)$ , and  $M_{-i\eta,1/2}(-2iqr)$ . The form of these representations makes them particularly well adapted to nuclear physics problems in which the Coulomb interaction is to be included in the final state of an amplitude already containing the strong-interaction pair rescattering. Each of these representations consists of two terms. The first is, apart from a constant factor, in the non-Coulomb function; the second term has the form of an integral over the momentum of the non-Coulomb function, and is manifestly zero when the Coulomb parameter is zero.

**21476.** Griffin, G. L.; Yates, J. T., Jr. Adsorption studies of  $H_2$  isotopes on ZnO: Coverage-induced IR frequency shifts and adsorbate geometry, *J. Chem. Phys.* 77, No. 7, 3744-3750 (Oct. 1, 1982).

Key words: chemisorption; hydrogen; IR frequency studies; zinc oxide.

The coverage dependence of the IR stretching frequencies for dissociative type I adsorption of  $H_2$  and  $D_2$  on ZnO powders has been measured using transmission IR spectroscopy. By comparing the frequency shifts observed when the isotopic composition of the adsorbate is varied at constant total coverage with the shifts observed when the total coverage of either pure component is varied, we can separate the dynamic and static contributions to the coverage-induced frequency shifts. The ZnH and ZnD shifts are due primarily to electrodynamic interactions. The observed shifts are in good agreement with the Hammaker model for dynamic dipole-dipole interactions, if adsorption is assumed to occur on  $(2 \times 2)$  reconstructed ZnO(0001) surface planes. In contrast, the OH and OD shifts are due to electrostatic and inductive interactions. The electrostatic contribution can be estimated using a modification of Buckingham's treatment of local environment effects. A qualitative model based on electron localization effects is presented to explain the observed inductive contribution.

**21477.** Benzinger, T. H. Temperature and thermodynamics of living matter, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 1389-1395 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: complete equation; Gibbs-Helmholtz equation; Planck thermodynamics; temperature; thermodynamics.

In this paper the driving energies of chemical reactions are identified as the constructive, *bond-forming* chemical bond energy  $\Delta H_0^0$  and the disruptive, *bond-breaking*, "Thermal Work Function"  $\Delta W^0(T) = T \int_0^T \{[\Delta C_p^0(T') \cdot dT'] / T'\} - \int_0^T \Delta C_p^0(T') \cdot dT'$ .

At one characteristic "Midpoint Temperature" ( $T_m$ ), defined by  $K(T_m) = 1$  or  $-RT \ln K(T_m) = 0$ , there is equilibrium between the bond-making and bond-breaking forces because  $\Delta H_0^0 = W^0(T_m)$ . At all other temperatures, the "Complete Equation for Chemical Equilibrium" is  $-RT \ln K(T) = \Delta H_0^0 - \{T \int_0^T [\Delta C_p^0(T') \cdot dT'] / T' - \int_0^T \Delta C_p^0(T') \cdot dT'\}$ .

( $C_p^0$  designates heat capacity at constant pressure, and  $\Delta H_0^0$  designates heat of reaction at absolute zero temperature.) Use of the complete equation permits thermodynamic treatment and comprehension of the multiple functions of living matter, the genetically coded macromolecules of proteins, polynucleotides and membranes, their weak interactions and reversible conformational changes at moderate temperatures. Treatment by means of the classical Gibbs-Helmholtz equation would not permit such understanding because it would disregard the second heat integral of the Complete Equation. In *micro* molecular reactions the second heat integral is small ( $3940 \text{ cal mol}^{-1}$  in the example of formation of boron iodide from the monoatomic elements in the gas phase compared with an enthalpy change of  $88443 \text{ cal mol}^{-1}$ ), and its omission from the Gibbs-Helmholtz equation would not cause serious misunderstandings. For *macromolecules* the Complete Equation must be used, and Planck thermodynamics will have to replace Gibbs-Helmholtz thermodynamics. Two numerical examples, the unfolding of a protein and unwinding of a polynucleotide double helix, are shown. For necessary background information, structures and functions of living matter are briefly discussed.

**21478.** Mangum, B. W. Triple point of gallium as a temperature fixed point, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 299-309 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: gallium; standard deviation; Teflon containers; temperature; triple-point.

The triple-point temperature of high-purity gallium has been determined to be  $29.77398^\circ\text{C}$  using five standard platinum resistance thermometers (SPRTs), recently dried and then calibrated on the IPTS-68, and using ten samples of gallium from three commercial sources. All data obtained on the highest-purity sample have a standard deviation of  $\pm 0.00014^\circ\text{C}$  and the systematic uncertainty is



estimated to be  $\pm 0.0006^\circ\text{C}$ . Three of the samples investigated were in all-plastic cells and seven samples were in steel cells with Teflon containers for the gallium and with Teflon-coated stainless-steel thermometer wells. Intercomparisons of the triple-point temperatures of all ten samples, each of a different lot, were made for several different gallium mantles of each sample.

- 21479.** Linsky, J. L.; Bornmann, P. L.; Carpenter, K. G.; Wing, R. F.; Giampapa, M. S.; Worden, S. P.; Hege, E. K. Outer atmospheres of cool stars. XII. A survey of *IUE* ultraviolet emission line spectra of cool dwarf stars, *Astrophys. J.* 260, 670-694 (Sept. 15, 1982).

Key words: stars, chromospheres; stars, emission-line; stars, flare; stars, late-type; ultraviolet, spectra.

We present and discuss *IUE* low dispersion spectra (1150-3200 Å) of four dM and six dMe stars, together with spectra of the first 10 Balmer lines and the Ca II H and K lines. From these calibrated spectra, we extract absolute line fluxes and surface fluxes for emission lines formed in the chromospheres ( $T < 20,000$  K) and transition regions ( $T = 20,000$ -200,000 K) of these stars. These data, together with data for four G-M dwarfs previously observed by *IUE* and the quiet Sun and solar plage regions, are intercompared to search for systematic trends. The Mg II resonance lines are the strongest chromospheric emission lines in dM stars and G-K dwarfs, but in the dMe stars the total emissions in the Ca II and Fe II lines are comparable and emission in the Balmer lines is several times larger than in Mg II. We find that the chromospheric radiative loss rates (and thus the heating rates) are typically 5 times larger in active (including dMe) than in quiet (including dM) stars, and that these rates decrease rapidly toward cooler stars. However, the fraction of the stellar luminosity that heats chromospheres for the chromospherically quiet stars appears to be constant over a wide range of effective temperature, and this fraction for the chromospherically active stars may increase a factor of 5-10 with decreasing effective temperature. By contrast, the fraction of the stellar luminosity that heats transition regions in active stars increases by a factor of 100 between solar plages and late dMe stars. A similar factor appears to be valid for coronae. Thus the process which heats stellar transition regions and coronae appears to be qualitatively different from that which heats chromospheres in G-M dwarfs. We find that the distribution of emission measure with temperature is similar to the quiet Sun in quiet G-K dwarfs and about one-third the quiet Sun value in dM stars. On the other hand, the distribution for active G-K dwarfs and dMe stars is similar to that of solar plages. Finally we note that the Balmer line fluxes and line profiles indicate large line center optical depths, consistent with the models of Cram and Mullan, and we find evidence for variability in dMe star active regions outside of flares.

- 21480.** Tsunekawa, S.; Kojima, T.; Hougen, J. T. Analysis of the microwave spectrum of hydrazine, *J. Mol. Spectrosc.* 95, 133-152 (1982).

Key words: hydrazine; matrix elements; microwave spectrum; rotational Hamiltonian.

Microwave measurements in the interval from 6 to 133 GHz, consisting of 444 rotational transitions in the vibrational ground state of hydrazine with  $J \leq 31$  and  $K_a \leq 6$  were fit to an effective rotational Hamiltonian containing 9 asymmetric rotor constants, 14  $\text{NH}_2$  inversion parameters, and 1 internal rotation parameter, with an overall standard deviation of the fit of 0.40 MHz. This set of parameters contains: (i) the three rotational constants; (ii) tunneling splitting constants for  $\text{NH}_2$  inversion at one end of the molecule, for  $\text{NH}_2$  inversion at both ends of the molecule, and for internal rotation through the *trans* barrier; (iii) two *K*-type doubling constants affecting the  $K=1$  levels; (iv) an *a*-type Coriolis interaction with matrix elements linear in *K*; and (v) various centrifugal distortion corrections to the above parameters. A consistent group theoretical formalism was used to label the energy levels and to select terms in the phenomenological rotational Hamiltonian. The Hamiltonian matrix, which is set up in a tunneling basis set, is of dimension  $16 \times 16$  and contains only  $\Delta K_a = 0$  matrix elements, asymmetric rotor effects being taken into account on the diagonal by terms from a Polo expansion in  $b^*$ . Hyperfine splittings and barrier heights are not discussed.

- 21481.** Griffin, G. L.; Yates, J. T., Jr. Coadsorption studies of CO and  $\text{H}_2$  on ZnO, *J. Chem. Phys.* 77, No. 7, 3751-3758 (Oct. 1, 1982).

Key words: adsorption; electrostatic; infrared spectroscopy; temperature.

We have studied the adsorption of pure CO and  $\text{CO:H}_2$  mixtures on powdered ZnO using the combined techniques of transmission infrared spectroscopy and temperature programmed desorption (TPD). When CO is adsorbed alone, the vibrational frequency  $\omega_{\text{CO}}$  decreases from 2192 to 2178  $\text{cm}^{-1}$  with increasing CO coverage, and a repulsive CO-CO interaction is observed in the TPD spectrum. When CO is adsorbed on an  $\text{H}_2$ -covered surface,  $\omega_{\text{ZnH}}$  decreases from 1709 to 1653  $\text{cm}^{-1}$ ,  $\omega_{\text{OH}}$  increases from 3490 to 3523  $\text{cm}^{-1}$ , and the zero-coverage limit of  $\omega_{\text{CO}}$  increases from 2191 to 2196  $\text{cm}^{-1}$ . There is also an increase in the CO adsorption energy due to an attractive CO- $\text{H}_2$  interaction. Analysis of TPD spectra for CO yields an expression for the CO adsorption energy as a function of CO and  $\text{H}_2$  coverage:  $\Delta H_{\text{ads}}^{\text{CO}}$  (kcal/mol) =  $12.2 - 0.16n_{\text{CO}} + 0.08n_{\text{H}_2}$ , where  $n_{\text{CO}}$  and  $n_{\text{H}_2}$  are the coverages in  $\mu\text{mol/gm}$ . We attribute the coverage dependence of the CO adsorption energy, as well as the observed IR frequency shifts, to both electrostatic and chemical interactions between adsorbates. The former arise from dipole interactions between neighboring species, while the latter are due to "through-substrate" inductive effects associated with the electron donating/withdrawing properties of each adsorbate.

- 21482.** Kline, W. F.; Enagonio, D. P.; Reeder, D. J.; May, W. E. Liquid chromatographic determination of valproic acid in human serum, *J. Liq. Chromatogr.* 5, No. 9, 1697-1709 (1982).

Key words: antiepilepsy drug; chromatographic; clinical laboratory; freeze dried material; serum matrix; valproic acid.

The concentration of the antiepilepsy drug valproic acid (2-propylpentanoic acid) was determined in both a processed freeze dried human serum material and patient serum samples obtained from a clinical laboratory. The freeze dried material is being issued by the National Bureau of Standards as Standard Reference Material 1599. The analytical procedure developed involves organic extraction of valproic acid and an internal standard (cyclohexanecarboxylic acid) from the serum matrix; derivatization of the carboxylic acids to phenacyl esters; measurement of the analyte and internal standard species by reversed-phase high performance liquid chromatography. The results obtained on both types of samples compare favorably with results obtained using more conventional gas chromatographic approaches.

- 21483.** Durst, R. A.; Blubaugh, E. A.; Bunding, K. A.; Fultz, M. L.; MacCrehan, W. A.; Yap, W. T. Organic electrochemical techniques having potential clinical application, *Clin. Chem.* 28, No. 9, 1922-1930 (1982).

Key words: bleomycin-metal complexes; chemically modified electrodes; electrochemical detector for liquid chromatography; mathematical models; organohalogen-sensitive electrodes; organomercury species; photoelectrocatalysis; spectroelectrochemistry; surface-enhanced Raman spectroscopy.

The Organic Electrochemistry Group at the National Bureau of Standards is pursuing several avenues of research of potential application to problems of clinical chemists. With one development, electrochemical detectors for liquid chromatography, organomercury species can be determined in biological tissues and other matrices. Spectroelectrochemistry is being used to characterize the redox behavior of metal complexes of bleomycin, an antitumor drug. Chemically modified electrodes are being developed as selective electrocatalytic sensors for organohalogen compounds and may lead to new sensors for clinically important analytes. Surface-enhanced Raman spectroscopy is helping characterize the polymer films used to modify the electrode surfaces. Another sensor is being developed for the detection of carboxylic acids: after the photocatalytic oxidation of the acids at a semiconductor electrode, the carbon dioxide produced is subsequently determined with a flow-through gas-sensing electrode. Finally, mathematical modeling may provide a better understanding of the fundamental processes involved in several of the above techniques.

- 21484.** Fultz, M. L.; Durst, R. A. Mediator compounds for the electrochemical study of biological redox systems: A compilation, *Anal. Chim. Acta* 140, 1-18 (1982).



Key words: biological compounds; mediators; redox behavior; redox mediators.

Many biological compounds exhibit irreversible redox behavior as a result of slow heterogeneous electron transfer at electrode surfaces. In order to study the electrochemical behavior of these biocomponents, redox mediators are used to facilitate the electron transfer process. In this review the characteristics of ideal mediators are discussed and structural information on previously reported mediator compounds is provided. The electrochemical literature has been extensively surveyed to provide an up-to-date compilation of mediators suitable for use in potentiometric and coulometric titrations and in various types of voltammetric studies of biological redox systems. The compilation provides information on the formal potentials of the mediators as well as their previous applications and references. This review is intended to provide a current survey of compounds having suitable redox mediation characteristics.

21485. Fritsch, F. N.; Kahaner, D. K.; Lyness, J. N. Double integration using one-dimensional adaptive quadrature routines: A software interface problem, *ACM Trans. Math. Softw.* 7, No. 1, 46-75 (Mar. 1981).

Key words: adaptive integration; automatic quadrature routine; double integration; quadrature; software interface.

A software interface problem occurs when two or more items of software are used in conjunction with one another. If proper advantage of using good software is to be gained, the user has to connect them properly. In this paper the problem of double integration employing two similar one-dimensional adaptive quadrature routines is considered. If an absolute error no greater than  $\epsilon_T$  in the final result is desired, it is necessary to determine what tolerance parameter  $\epsilon_O$  to assign to the outer routine and what tolerance parameters  $\epsilon_I$  to assign for calls to the inner routine. Since it is not known at the outset how many times the inner routine will be called, there is required what is termed an *accuracy assignment strategy* for determining  $\epsilon_I$ . In this paper two simple accuracy assignment strategies are discussed in detail. It is shown that one of them can be unstable if the outer routine is constructed internally in one way (local error control), but that it is quite stable if it is constructed in another way (global error control). It is also found that one of the strategies is marginally more efficient for visually smooth integrands, while the other is significantly more efficient for peaked integrands.

21486. Gadzik, J. W.; Landman, U.; Kuster, E. J.; Cleveland, C. L.; Barnett, R. N. Infinite conical well: An analytic model for quantum mechanical hindered rotors, *Phys. Rev. Lett.* 49, No. 7, 426-430 (Aug. 16, 1982).

Key words: analytic model; hindered rotors; infinite conical well.

The rotational quantum mechanics of a new analytic model for a hindered rotor is presented, and rotational-state distributions of the hindered rotor are given in terms of unhindered rotor states.

21487. Hummer, D. G.; Barlow, M. J.; Storey, P. J. The infrared recombination-line spectra of Wolf-Rayet stars, (Proc. IAU Symp. Wolf-Rayet Stars, Cancun, Mexico, Sept. 1981), Paper in *Wolf-Rayet Stars: Observations, Physics, Evolution*, C. W. H. de Loore and A. J. Willis, eds., pp. 79-83 (Reidel, Dordrecht Holland, 1982).

Key words: infrared; infrared spectra; stars; Wolf-Rayet atmospheres.

Effective recombination coefficients have recently been calculated for recombination lines of He I, He II and C IV (among other ions with up to three electrons) for densities and temperatures appropriate for Wolf-Rayet atmospheres. These have been applied to recently obtained infrared spectra of  $\gamma$  Vel in order to derive the  $\text{He}^+/\text{He}^{+2}$  and  $\text{C}^{+4}/\text{He}^+ + \text{He}^{+2}$  ratios.

21488. Soulen, R. J., Jr. Millikelvin temperature standards, (Proc. 16th Int. Conf. Low Temperature Physics, University of California, Los Angeles, CA, Aug. 19-25, 1981), *Physica* 109 & 110B, 2020-2030 (1982).

Key words: millikelvin region; standards; temperature.

The status of temperature scales, fixed points and interpolation devices for the millikelvin region of temperature (approximately 1 mK to 500 mK) is reviewed. On the basis of recent comparisons of temperature scales by means of fixed points it appears that inaccuracies in temperature of 0.5% or less prevail at the upper end of this region and they increase steadily to a level of 5% at the lower end.

21489. Johnson, R. G.; Bowman, C. D. Inelastic-scattering measurements of 1.5-15 eV neutrons, *Phys. Rev. Lett.* 49, No. 11, 797-800 (Sept. 13, 1982).

Key words: electronvolt; inelastic-scattering; liquid nitrogen; neutrons.

Measurements of inelastically scattered electronvolt neutrons have been completed with a pulsed neutron source and neutron time-of-flight techniques in combination with a resonant-neutron-capture detector. Measurements are presented on liquid nitrogen and benzene for incident neutron energies in the range 1.5 to 15 eV and for  $q$  values for 13 to 120  $\text{\AA}^{-1}$ . These are the first measurements of inelastic neutron scattering in this energy range.

21490. Stockbauer, R.; Hanson, D. M.; Flodström, S. A.; Madey, T. E. Photon-stimulated desorption and ultraviolet photoemission spectroscopic study of the interaction of  $\text{H}_2\text{O}$  with a Ti(001) surface, *Phys. Rev. B* 26, No. 4, 1885-1892 (Aug. 15, 1982).

Key words: interaction; photon-stimulated desorption; single crystal; ultraviolet photoemission.

The adsorption of  $\text{H}_2\text{O}$  on a stepped Ti(001) single crystal, oriented within  $4^\circ$  of Ti(001) has been studied using synchrotron radiation from the Synchrotron Ultraviolet Radiation Facility at National Bureau of Standards. The species formed upon adsorption of  $\text{H}_2\text{O}$  were identified through variable-wavelength ultraviolet photoemission spectroscopy. At room temperature ( $\sim 300$  K), water dissociates to form O, H, and OH. At low temperature ( $\sim 90$  K) and low coverage ( $< 1$  L), the same species were observed. Photon-stimulated-desorption experiments were performed under these conditions yielding predominately  $\text{H}^+$  ions with little or no  $\text{OH}^+$  or  $\text{O}^+$ . At 90 K and coverages greater than 1 L, an ice overlayer was formed suppressing the  $\text{H}^+$ -ion desorption. Separate experiments involving the adsorption of hydrogen and coadsorption of oxygen and hydrogen showed an order of magnitude less  $\text{H}^+$  desorption, indicating that the  $\text{H}^+$  desorption was associated with the presence of OH on the surface. The  $\text{H}^+$ -ion yield as a function of photon energy showed a threshold at 25 eV perhaps due to O 2s excitation. A second threshold at 33 eV, a broad peak near 45 eV, and a slow decrease toward higher photon energy suggests a correlation with the Ti 3p core-hole excitation although other possibilities cannot be eliminated. Possible bonding configurations are proposed to explain the origins of the  $\text{H}^+$  emission.

21491. Faller, J. E. Tunnel detection utilizing field-stationary gravity gradiometers, *Proc. Symp. Tunnel Detection, Colorado School of Mines, Golden, CO, July 21-23, 1981*, pp. 247-257 (1982).

Key words: astrophysics; gravity gradiometers; torsion pendulum apparatus; tunnel detection.

At the Joint Institute for Laboratory Astrophysics, we have developed a new type of torsion pendulum apparatus. The initial motivation was to improve the accuracy of the Eötvös (equivalence of gravitational and inertial mass) experiment. In this torsion pendulum apparatus, the traditional fiber is replaced with a surrogate in which the fiber's suspension role is provided entirely by a fluid while its restoring and centering functions are achieved by an appropriate electrode array subject to adjustable voltages. Slight modifications of this design result in a low cost gravity gradiometer of potentially very high sensitivity. We are now constructing—for purposes of testing the concept—two fluid gradiometers of a size such that, theoretically, their sensitivities will permit one to see the change in gravity gradient resulting from a tunnel at a distance of one kilometer. The status of this development will be discussed.

21492. Norcross, D. W. Magnetohydrodynamic electrical power



Key words: applied physics; collision physics; magnetohydrodynamics.

Applications of collision physics to the development of magnetohydrodynamic electrical power generating systems are reviewed. The technical areas in which collision physics relates most directly involve the characterization and modeling of the bulk plasma. Some of these are the gas-phase chemistry that determines the plasma composition and its thermodynamic properties, and the collision process that determine the electrical conductivity.

**21493.** Robinson, E. L.; Nather, R. E.; Kepler, S. O. BT monocerotis: An eclipsing nova, *Astrophys. J.* 254, No. 2, 646-652 (Mar. 15, 1982).

Key words: stars, eclipsing binaries; stars, individual; stars, novae.

Our photometric observations of BT Mon (=Nova Mon 1939) demonstrate that it is an eclipsing binary system with an orbital period of 0.3338141 days. We show that the accretion disk in BT Mon is exceptionally large and luminous. Its radius is within 60% of the radius of its Roche lobe and is at least 3 times larger than the radius of a zero-viscosity disk; and its absolute visual magnitude is  $4.0 \pm 1.0$ , which requires a mass flux greater than  $2 \times 10^{-8} M_{\odot} \text{ yr}^{-1}$ . The late-type star in BT Mon cannot simultaneously fit a main-sequence mass-radius relation and a main-sequence mass-luminosity relation, in the sense that it is underluminous for a normal main-sequence star.

**21494.** Agarwal, G. S.; Friberg, A. T.; Wolf, E. Effect of backscattering in phase conjugation with weak scatterers, *J. Opt. Soc. Am.* 72, No. 7, 861-863 (July 1982).

Key words: backscattering; Born approximation; phase conjugation.

An extension is presented of a recently developed theory (based on the first Born approximation) of cancellation of distortions by phase conjugation. The influence of backscattering of both the incident and the conjugate waves is considered. It is shown that, when backscattering is taken into account, distortions are not eliminated by phase conjugation, except when the conjugate wave is generated without a loss or a gain.

**21495.** Robinson, E. L.; Kepler, S. O.; Nather, R. E. Multicolor variations of the ZZ Ceti stars, *Astrophys. J.* 259, No. 1, 219-231 (Aug. 1, 1982).

Key words: line profiles; stars, pulsation; stars, variables; stars, white dwarfs.

Although the ZZ Ceti stars, or pulsating white dwarfs, are usually thought to be pulsating in the nonradial  $g$ -modes, this conclusion is based entirely on the observed periods of the pulsations. Very little attention, either theoretical or observational, has been given to the spectral and multicolor variations of the ZZ Ceti stars. Therefore, in the first part of this paper we calculate the theoretical color, radial velocity, and line profile variations of a white dwarf undergoing  $g$ -mode pulsations. We find that the luminosity and color variations of the white dwarf are caused by its temperature variations, not by its geometry or gravity variations. We also find that the variations in the profiles and radial velocities of the absorption lines in the spectrum of the white dwarf will be too small to be measured. This lack of variation in the line profiles and velocities should unambiguously distinguish the  $g$ -mode pulsations from the  $r$ -mode pulsations. In the second part of this paper we report the results of our multicolor photometry of the ZZ Ceti star R548. We find that, to within the observational errors, the luminosity variations of R548 are consistent with temperature variations. Thus, we conclude that the properties of the pulsations of R548 are consistent with the expected properties of  $g$ -mode pulsations.

**21496.** Kepler, S. O.; Robinson, E. L.; Nather, R. E.; McGraw, J. T. The pulsation periods of the pulsating white dwarf G117-B15A, *Astrophys. J.* 254, No. 2, 676-682 (Mar. 15, 1982).

Key words: stars, individual; stars, pulsation; stars, white dwarfs.

G117-B15A is a pulsating DA white dwarf, or ZZ Ceti-type star.

Using high-speed photometry accumulated over the 5 year interval from 1975 to 1980, we have disentangled the unusually complex variations of its light curve. G117-B15A has six pulsation modes simultaneously excited with periods of 107.6 s, 119.8 s, 126.2 s, 215.2 s, 271.0 s, and 304.4 s. The 215.2 s pulsation has the largest semiamplitude, 0.022 mag, of the six pulsations and dominates the light curve. The upper limit to the rate of change of the period of this large amplitude pulsation is  $|P| < 7.8 \times 10^{-14} \text{ s s}^{-1}$  at the 68% confidence level. The pulsations of the ZZ Ceti stars are usually considered to be the nonradial  $g$ -mode pulsations. Our upper limit to  $|P|$  is consistent with this idea, but the ratios of the periods can be understood more easily if the pulsations are  $r$ -modes than if they are  $g$ -modes.

**21497.** Mandel, J. Use of the singular value decomposition in regression analysis, *Am. Stat.* 36, No. 1, 15-24 (Feb. 1982).

Key words: collinearity; multiple linear regression; principal component regression; singular value decomposition.

Principal component analysis, particularly in the form of singular value decomposition, is a useful technique for a number of applications, including the analysis of two-way tables, evaluation of experimental design, empirical fitting of functions, and regression. This paper is a discussion in expository form of the use of singular value decomposition in multiple linear regression, with special reference to the problems of collinearity and near collinearity.

**21498.** Giampapa, M. S.; Worden, S. P.; Linsky, J. L. Stellar model chromospheres. XIII. M dwarf stars, *Astrophys. J.* 258, No. 2, 740-760 (July 15, 1982).

Key words: Ca II emission; stars, chromospheres; stars, late-type.

We construct single-component, homogeneous model chromospheres that are consistent with high-resolution profiles of the Ca II K line calibrated in surface flux units for three dMe and 2 dM stars observed at quiescent times.

Our models reveal several systematic trends. We derive large values of  $T_{\text{min}}/T_{\text{eff}}$  indicating a large amount of nonradiative heating present in the upper photospheres of M dwarf stars. We also find that the lower chromospheric temperature gradient is similar for all the M dwarf stars. Since for our models the chromospheric K line emission strength is most sensitive to the total amount of chromospheric material present within the approximate temperature range  $T_{\text{min}} - 6000 \text{ K}$ , increasing the emission strength is not simply due to increasing chromospheric temperature gradients. We also find that both the electron density and electron temperature at one thermalization length in the K line below the top of the chromospheres are greater in the dMe stars than in the dM stars. Our M dwarf models have microturbulent velocities between 1 and 2  $\text{km s}^{-1}$ , which are much smaller than for solar chromosphere models. We also compute H $\alpha$  and the Mg II  $h$  and  $k$  lines, and estimate relative active region filling factors on the basis of the observed fluxes.

**21499.** Linsky, J. L. The structure and energy balance of cool star atmospheres, (Proc. Advances in Ultraviolet Spectroscopy: Four Years of IUE Research, Greenbelt, MD, Mar. 20-Apr. 1, 1982), *NASA Conf. Publ.* 2238, pp. 17-32 (Goddard Space Flight Center, Greenbelt, MD, 1982).

Key words: atmospheres; flux tubes; IUE observations; stars.

A broad theme emerging from IUE observations of cool stars is that magnetic fields control the structure and energy balance of the outer atmospheres of these stars. For this review I summarize the phenomena associated with magnetic fields in the Sun and show that similar phenomena occur in cool stars. Gross atmospheric structures similar to the solar chromosphere and transition region occur in dwarf stars cooler than early F and perhaps in hotter stars. I will discuss the evidence for the weakening or disappearance of transition regions and coronae, together with the appearance of extended cool chromospheres with large mass loss, near  $V-R=0.80$  in the H-R diagram. Like the solar atmosphere, these atmospheres are not homogeneous and there is considerable evidence for plage regions with bright TR emission lines that overlie dark (presumably magnetic) star spots. The IUE observations are also providing important information on the energy balance in these atmospheres that should guide theoretical calculations of the nonradiative heating rate. Recent high dispersion spectra are providing unique information concerning



which components of close binary systems are the dominant contributors to the observed emission, as well as estimates of densities and atmospheric extension. Emission line widths appear to increase with line formation temperature and luminosity, indicating properties of the random motions in these stars and that some resonance lines are opacity broadened. A recent unanticipated discovery is that the transition lines are redshifted (an antiwind) in  $\beta$  Dra (G2 Ib) and perhaps other stars, which I interpret as indicating downflows in closed magnetic flux tubes as are seen in the solar flux tubes above sunspots. Finally I classify the G and K giants and supergiants into three groups—active stars, quiet stars, and hybrid stars—depending on whether their atmospheres are dominated by closed magnetic flux tubes, open field geometries, or a predominately open geometry with a few closed flux tubes embedded.

**21500.** Hammer, R.; Linsky, J. L.; Endler, F. **On the correlation between chromospheric and coronal emission**, (Proc. Advances in Ultraviolet Spectroscopy: Four Years of *IUE* Research, Greenbelt, MD, Mar. 20-Apr. 1, 1982), *NASA Conf. Publ.* 2238, pp. 268-272 (Goddard Space Flight Center, Greenbelt, MD, 1982).

Key words: chromospheric emission; corona; coronal emission; energy flux; stellar activity.

According to empirical chromospheric models, the mechanical (magnetic and nonmagnetic) energy flux  $F_M$  decreases over large parts of the solar chromosphere less rapidly than the pressure  $p$  ( $d \log F_M / d \log p < 1$ ). The total energy loss  $F_{Loss}$  of the transition region and corona, on the other hand, increases faster than the pressure,  $p_{TR}$ , of the transition region ( $d \log F_{Loss} / d \log p_{TR} > 1$ ), as is indicated by theoretical models of coronal loops and open coronal regions as well as by semiempirical studies. Therefore, the relation  $d \log F_M / d \log p < d \log F_{Loss} / d \log p_{TR}$  appears to be generally valid. In the present study we discuss the implications of this relation. We show that it explains qualitatively the recent observational result of Ayres, Marstad and Linsky (1981) that with increasing stellar activity the emission of the transition region and corona increases faster than the emission of the chromosphere. It also explains why the pressure of the transition region increases with increasing stellar activity. Further, we show that this relation is a necessary requirement for the global stability of the chromosphere/transition region/corona system.

**21501.** Marstad, N.; Linsky, J. L.; Simon, T.; Rodono, M.; Blanco, C.; Catalano, S.; Marilli, E.; Andrews, A. D.; Butler, C. J.; Byrne, P. B. **Results of an *IUE* program of monitoring the ultraviolet emission line fluxes of four binary systems: HR 1099, II Peg, AR Lac, and BY Dra**, (Proc. Advances in Ultraviolet Spectroscopy: Four Years of *IUE* Research, Greenbelt, MD, Mar. 20-Apr. 1, 1982), *NASA Conf. Publ.* 2238, pp. 554-557 (Goddard Space Flight Center, Greenbelt, MD, 1982).

Key words: binaries; optical photometry; spectra; stars; ultraviolet emission.

We present a preliminary report on a collaborative program to obtain *IUE* spectra and optical photometry and spectra of three RS CVn-type binaries (HR 1099, II Peg, and AR Lac) and the prototype BY Dra system. We monitored these systems for at least one orbital phase, and detected periodic variations in emission line flux from II Peg and HR 1099, indicative of rotational modulation of an active region on these stars. For II Peg the active region is in phase with photometric minimum as expected, but for HR 1099 ultraviolet emission maximum occurs at the time of photometric maximum.

**21502.** Ayres, T. R.; Linsky, J. L.; Brown, A.; Jordan, C.; Simon, T. **High dispersion *IUE* spectra of active chromosphere G and K dwarfs**, (Proc. Advances in Ultraviolet Spectroscopy: Four Years of *IUE* Research, Greenbelt, MD, Mar. 20-Apr. 1, 1982), *NASA Conf. Publ.* 2238, pp. 281-284 (Goddard Space Flight Center, Greenbelt, MD, 1982).

Key words: active chromosphere; dwarf stars; high dispersion *IUE* spectra.

We analyze *IUE* far ultraviolet echelle spectra of three active chromosphere dwarf stars:  $\chi^1$  Orionis (G0 V),  $\xi$  Boötis A (G8 V), and  $\epsilon$  Eridani (K2 V), utilizing spectra of  $\alpha$  Cen A (G2 V) and  $\alpha$  Cen B (K1 V) as quiet chromosphere comparisons.

**21503.** Simon, T.; Linsky, J. L. **Ultraviolet observations of yellow giant stars**, (Proc. Advances in Ultraviolet Spectroscopy: Four Years of *IUE* Research, Greenbelt, MD, Mar. 20-Apr. 1, 1982), *NASA Conf. Publ.* 2238, pp. 273-276 (Goddard Space Flight Center, Greenbelt, MD, 1982).

Key words: coronal emission; emission; temperature; ultraviolet observations; yellow giant stars.

Low-dispersion spectra of 18 yellow giant stars of spectral types G4-K0 were obtained with the short wavelength camera of *IUE*. Using the emission strength of the C IV 1550 Å multiplet as a measure of high temperature  $10^5$  K plasma, we find that the normalized C IV flux,  $f_{C\ IV} / I_{bol}$ , where  $I_{bol}$  is the apparent stellar bolometric flux, is typically  $10^{-7}$  or smaller, indicating very feeble stellar transition regions. By combining these results with earlier data from *IUE*, we show that there is nearly a two orders of magnitude spread in  $f_{C\ IV} / I_{bol}$  among the yellow giants. Several likely reasons for the observed range in high-temperature emission line strengths are discussed; the more likely appears to be that the majority of the yellow giant stars observed are slow rotators evolving across the Hertzsprung Gap for the second time along a blue loop.

**21504.** Stencel, R. E.; Linsky, J. L.; Ayres, T. R.; Jordan, C.; Brown, A.; Engvold, O. **High dispersion far ultraviolet spectra of cool stars**, (Proc. Advances in Ultraviolet Spectroscopy: Four Years of *IUE* Research, Greenbelt, MD, Mar. 20-Apr. 1, 1982), *NASA Conf. Publ.* 2238, pp. 259-262 (Goddard Space Flight Center, Greenbelt, MD, 1982).

Key words: cool stars; electron density; emission lines; high dispersion; high resolution spectra; outer atmosphere; ultraviolet spectra.

We discuss recent far UV high dispersion spectra of two cool supergiant stars, Beta Dra (G2 Ib) and Alpha Ori (M2 Iab), which are examined in the context of current questions regarding stellar chromospheres, coronae and mass loss. These stars show very different outer atmosphere structure. Beta Dra has a geometrically thin transition region with bright emission lines of  $10^5$  K plasma that are red-shifted, indicating downflow in magnetic flux tubes. By contrast, Alpha Ori has a cool extended chromosphere and circumstellar envelope with large mass loss.

**21505.** Mountain, R. D.; Birnbaum, G. **Inhomogeneity size and shape determination from scattering of low-frequency sound waves**, *J. Appl. Phys.* 53, No. 5, 3581-3584 (May 1982).

Key words: Born approximation; scattering; size and shape determination; sound waves; wave vectors.

The scattering of sound waves by isolated inhomogeneities in a solid is examined using the Born approximation. A procedure is developed to extract information about the effective volume and shape of the scatterer. The procedure uses data from the long-wavelength region where this approximation is valid. The volume and shape information is in the form of special moments of the volume of the scatterer which depend on the orientation of the scatterer relative to the direction of the difference in the incoming and outgoing wave vectors. A scheme is described which permits the characterization of the scatterer in terms of an equivalent ellipsoid. The scheme provides a second-moment solution of the inverse scattering problem.

**21506.** Schmidt, W. F.; Van Brunt, R. J. **Comments on the effect of electron detachment in initiating breakdown in gaseous dielectrics**, *Proc. Third Int. Symp. on Gaseous Dielectrics*, Knoxville, TN, Mar. 7-11, 1982, pp. 561-563 (Pergamon Press, 1982).

Key words: breakdown; collisions; detachment; gas discharges; negative ions; radiation.

This paper represents a summary of the deliberations of a small group discussion meeting held at the Third International Symposium on Gaseous Dielectrics. The relative importance of various electron detachment processes in the initiation of electrical breakdown in electronegative gases is considered and discussed.

**21507.** Senich, G. A. **Chromatographic studies of diffusion in polymers**, *Proc. Int. Union of Pure and Applied Chemistry, 28th Macromolecular Symp.*, Amherst, MA, July 12-16, 1982, p. 740 (IUPAC Macro 82,



**Key words:** alkanes; diffusion; gas chromatography; inverse gas chromatography; migration; oligomers; polyethylene; polymers.

The method of inverse gas chromatography is considered as a means for obtaining diffusion coefficients of volatile organic materials or probes in polymers. Experimental studies of the chromatographic peak broadening dependence on carrier gas flow rate allow the diffusivity of the probe in the polymer to be determined. The results of previous studies on octadecane diffusion in high-density polyethylene (HDPE) are summarized. Methods for studying the diffusivity of a probe relative to that of a reference probe in a polymer of interest are discussed. Results are presented for the diffusion of several normal and branched alkanes from tridecane through octadecane in HDPE.

- 21508.** Swartzendruber, L. J.; Boettinger, W. J.; Ives, L. K.; Coriell, S. R.; Mehrabian, R. Relationship between process variables, microstructure and NDE of a precipitation-hardened aluminum alloy, *Proc. Nondestructive evaluation: Microstructural Characterization and Reliability Strategies*, Pittsburgh, PA, Oct. 5-9, 1980, pp. 253-271 (Metallurgical society of AIME, Box 430, Warrendale, PA 15086, 1980).

**Key words:** aluminum alloy plates; electrical conductivity; heat flow; mechanical properties and conductivity; microstructure; nondestructive evaluation.

The compositional homogeneity, microstructure, hardness, electrical conductivity and mechanical properties of 2219 aluminum alloy plates are influenced by the process variables during casting, rolling and thermomechanical treatment. The details (1) of these relationships have been investigated for correctly processed 2219 plate as well as for deviations caused by improper quenching after solution heat treatment. A detailed blend of metallurgical examination of the alloy was carried out in conjunction with NDE studies to gain a fundamental knowledge of the features of metallurgical microstructures which cause changes in NDE response. Primary emphasis has been placed on the reliability of eddy current electrical conductivity and hardness as NDE tools to detect variations in mechanical properties.

- 21509.** Meijer, P. H. E.; Ekmekci, S. The phase diagram of simple metamagnets as determined by the cluster variation method, *Physica* **113A**, 351-366 (1982).

**Key words:** bicritical endpoints; cluster variation method; Lifshitz point; metamagnets; phase diagram; simple Ising metamagnet.

In order to explore the global properties of a simple Ising metamagnet we computed the values of the coupling parameters for which the tricritical behavior is replaced by bicritical endpoints (Lifshitz point). The transition points are determined by means of the cluster variation method. The metamagnets studied have an antiferromagnetic coupling between the spins on two chosen sublattices and a ferromagnetic coupling between spins on the same sublattice. The following lattices and sublattices were considered: two-dimensional square, simple cubic and two different subdivisions of the fcc and bcc lattices each. The method used is based on the coincidence of two roots for the bicritical endpoints and of three roots for the tricritical point. In contrast to the molecular field and the pair approximation results, the presence or absence of the Lifshitz point depends on the lattice structure considered. We discuss the comparison of our results with the results from the renormalization theories.

- 21510.** Krasny, J. F.; Braun, E. Textile flammability testing: Appropriate levels for moisture content of specimens, *Fire Mater.* **6**, No. 1, 38-41 (1982).

**Key words:** fabric specimens; flammability; garments; humidity; moisture content; textile flammability testing.

This study was performed to establish the appropriate moisture level for textile flammability test specimens. Three investigations were carried out: into the effect of the level of humidity in dwellings; into the moisture content of garments worn at various distances from the

body; and into the effect of relatively short exposures to heat on the moisture content of fabrics (simulating the case of a person standing in front of an open fire or space heater). The moisture content of ambient air in dwellings was found to be primarily governed by the moisture content of the air outside and can be quite low, ten to twenty percent, especially in winter (unless, of course, humidifying equipment is used). The moisture content of garment parts which are at some distance from the body (e.g., the loosely fitting parts of skirts) is governed by the relative humidity of the room. Closely fitting parts are more likely to be exposed to ignition sources than closely fitting parts. Fabric specimens exposed at a short distance from an electric space heater had moisture contents similar to specimens which had been over-dried and cooled in a desiccator. The results of these studies indicate that oven-drying is a reasonable conditioning requirement for testing the flammability of apparel and home furnishing fabrics.

- 21511.** Foley, G. M.; Morse, M. S.; Cezairliyan, A. Two-color microsecond pyrometer for 2000 to 6000 K, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 447-452 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

**Key words:** linearity of measurements; microsecond-resolution pyrometers; pulse heating; pyrometer; radiation; spectral radiance temperature.

An accurate pyrometer has been developed for measurements on solid and liquid specimens in the range 2000 to 6000 K. The pyrometer measures spectral radiance temperature near 0.65 and 0.9  $\mu\text{m}$ . Fiber optic cables transmit the radiation to silicon diode detectors. In each channel, a set of three linear amplifiers with high-speed automatic gain switching give high resolution and wide temperature range. Signals are digitally recorded with 0.1% resolution at 1.5  $\mu\text{s}$  intervals. Linearity of measurements of radiance has been confirmed using a calibrated tungsten strip lamp and the Sun. Characteristics and performance of the pyrometer are discussed and results on pulse heating of metallic specimens beyond the melting point are presented.

- 21512.** Sniegowski, L. T.; White V, E.; Konash, P. L. Synthesis of 2-naphthalene- $d_7$ -sulfonic acid, *J. Labelled Compds. Radiopharmaceut.* **XIX**, No. 9, 1081-1087 (1982).

**Key words:** deuterium labeling; liquid chromatography; mass spectra; 2-naphthalene- $d_7$ -sulfonic acid.

2-naphthalene- $d_7$ -sulfonic acid, required as an internal standard for the analysis of organic compounds in water by gas chromatography/mass spectrometry, was synthesized in one step from commercially available naphthalene- $d_8$  and sulfuric acid- $d_2$ . A high-performance liquid chromatographic method was developed to separate 1- and 2-naphthalene- $d_7$ -sulfonic acids. The electron impact mass spectrum and isotopic purity of the 2-naphthalene- $d_7$ -sulfonic acid were determined.

- 21513.** Evans, D. D. Sprinklers come home at last, *Fire Service Today* **49**, No. 10, 14-16 (Oct. 1982).

**Key words:** fire extinguishment; fire protection; mobile home; sprinkler heads; sprinkler system.

Two full-scale room fire tests conducted to demonstrate the performance of a new low-cost residential sprinkler system are described. These tests were conducted in Springdale, Arkansas on August 1, 1981 as part of the Federal Emergency Management Agency Operation Dixieland program. The residential sprinkler system extinguished both living room and bedroom test fires confining damage to the immediate area around on newspaper filled plastic waste paper container used as the ignition source.

- 21514.** Boettinger, W. J. Growth kinetic limitations during rapid solidification, (Proc. Materials Soc., Boston, MA, Nov. 11-16, 1981), Paper in *Rapidly Solidified Amorphous and Crystalline Alloys*, B. H. Kear, B. C. Giessen, and M. Cohen, eds., pp. 15-31 (Elsevier Science Publ. Co., Inc., 1982).

**Key words:** dendritic growth; eutectic growth; interface kinetics;



partitionless solidification; rapid solidification.

The importance of growth kinetics in the development of the microstructure of rapidly solidified alloys is described. Growth kinetics are conveniently divided into diffusion kinetics and interface attachment kinetics. The former, which are used extensively for the analysis of slow rate solidification, can be extended to high solidification rates to predict some microstructural features; e.g., the limitations on eutectic growth rate which can promote the formation of metallic glass, and the reduction of microsegregation. At the highest rates interface attachment kinetics must be included. Some microstructural effects of the velocity dependence of the partition coefficient will be described.

**21515.** Larché, F. C.; Cahn, J. W. The effect of self-stress on diffusion in solids, *Acta Metall.* 30, 1835-1845 (1982).

Key words: diffusion; Fick's law; interstitial; stress field; thermodynamics; thin films.

We demonstrate that the local diffusion flux in solids depends on stresses arising from compositional inhomogeneities (and even the shape) of the entire specimen. This dependence of local flux on distant inhomogeneity is considered to be a failure of Fick's law. From an equation relating stress and composition field, we can find special cases in which a diffusion law resembling Fick's law occurs, but the anisotropy of the apparent diffusion coefficient reveals that non-local factors are still present. We also examine the case of diffusion through a thin plate for the functional dependence of diffusion on the composition field and predict much deeper diffusional penetration and accumulation on the far side.

**21516.** Coriell, S. R.; Sekerka, R. F. Effect of convective flow on morphological stability, *PCH Physicochem. Hydrodyn.* 2, No. 4, 281-293 (1981).

Key words: alloy; convection; crystal growth; fluid flow; solidification; stability.

The theory of morphological stability pertains to the dynamics of the spontaneous change in shape of a two-phase interface during a phase transformation. For crystal growth from the melt, the parent phase is a liquid; therefore, the transport of heat and solute can take place by both diffusion and convection. For forced convection, the fluid flow is dominated by external forces and the solid-liquid interface is captive to this flow. This situation has been modeled by either a stagnant boundary layer or a boundary layer in which a parallel flow is perturbed by the solid-liquid interface shape. Forced convection sometimes gives rise to both modifications in the criterion for instability and in the dynamics of instability, the principal feature of the latter being the possibility that a perturbation can grow laterally because of the bias introduced by the forced flow. In the absence of forced convection, natural convection, driven by variations of density with temperature and solute content, can take place. Were it not for the solidification aspects, this natural convection would result from the classical Bénard instability, including the possibility of thermosolutal convection. When solidification is admitted, the solidification boundary conditions at the solid-liquid interface serve to couple the classical hydrodynamic and interfacial stability phenomena. For low rates of solidification, a long wavelength convective-like instability occurs at a critical solute concentration that generally increases with increasing rate. For much higher solidification rates, a short wavelength morphological-like instability occurs at a critical solute concentration that decreases with increasing growth rate, a behavior familiar from the criterion of constitutional supercooling. At intermediate wavelengths, unstable oscillatory modes can occur, because of a subtle coupling of the hydrodynamic and morphological instabilities.

**21517.** Fang, J. B. Repeatability of large-scale room fire tests, *Fire Technol.* 17, No. 1, 5-16 (Feb. 1981).

Key words: coefficient of variation; fire tests; furniture; gas temperature; heat flux; heat release rate; interior finish; repeatability; room fire.

Statistical analysis was performed on the experimental results of four full-scale room fire tests from a series of floor-ceiling assembly fire resistance tests conducted in a basement recreation room.

**21518.** Fried, A.; Hodgeson, J. Laser photoacoustic detection of nitrogen dioxide in the gas-phase titration of nitric oxide with ozone, *Anal. Chem.* 54, No. 2, 278-282 (Feb. 1982).

Key words: gas phase titration; intercomparison of measurement standards; laser photoacoustic; NO<sub>2</sub> detection; photoacoustic; spectroscopy.

Gas-phase titration (GPT) studies of nitric oxide (NO) with ozone (O<sub>3</sub>) were carried out over a 1 year time span. In these studies, NO and O<sub>3</sub> concentrations were measured with conventional techniques of chemiluminescence and UV absorption photometry, respectively. Nitrogen dioxide concentrations (NO<sub>2</sub>) also measured during the course of titration were carried out by use of a photoacoustic detection system, a method in which NO<sub>2</sub> was measured directly without an interfering response from NO. Excellent agreement in NO and NO<sub>2</sub> concentration changes during titration has been demonstrated throughout this study. The corresponding O<sub>3</sub> measurements, however, were found to average 3.6% lower. Additional studies, both experimental and photochemical modeling of air stream impurities, could not account for this discrepancy.

**21519.** Kafadar, K. Using biweight M-estimates in the two-sample problem. Part 1: Symmetric populations, *Commun. Statist. Theor. Meth.* 11, No. 17, 1883-1901 (1982).

Key words: Monte Carlo simulation; robust confidence intervals; robustness of efficiency; robustness of validity; statistical methods; student's-t statistic.

We propose replacing the usual Student's-t statistic, which tests for equality of means of two distributions and is used to construct a confidence interval for the difference, by a biweight-"t" statistic. The biweight-"t" is a ratio of the difference of the biweight estimates of location from the two samples to an estimate of the standard error of this difference. Three forms of the denominator are evaluated: weighted variance estimates using both pooled and unpooled scale estimates, and unweighted variance estimates using an unpooled scale estimate. Monte Carlo simulations reveal that resulting confidence intervals are highly efficient on moderate sample sizes, and that nominal levels are nearly attained, even when considering extreme percentage points.

**21520.** Fitzpatrick, G. J.; Forster, E. O.; Kelley, E. F.; Hebner, R. E. Effects of chemical impurities on prebreakdown events in toluene, *Proc. 1982 Annu. Report Conf. Electrical Insulation and Dielectric Phenomena, Amherst, MA, Oct. 17-21, 1982*, pp. 464-472 (IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854, Oct. 1982).

Key words: breakdown; electrical insulation; liquid insulation; resistivity; streamer; toluene.

Effects of chemical impurities on the breakdown process in toluene have been investigated under non-uniform field conditions using a high-speed image converter camera. The resistivity of the four samples investigated ranged from 10<sup>9</sup> to 10<sup>13</sup> Ω cm. It was noted that when the cathode was a point, streamer growth rate increased slightly with decreasing resistivity. When the needle was an anode, streamer growth rate was not measurably affected by changes in resistivity or applied voltage, requiring 1.6±0.3 μs to cross the 3 mm gap. Independent of the polarity of the needle, the last step in the traverse leading to breakdown of the gap occurred at speeds greater than 1×10<sup>6</sup> cm/s. In purified toluene, more than 200 kV could be applied to a 3 mm gap without breakdown. With the needle as a cathode, impurities facilitated the generation of secondary streamers which appeared to grow from the primary bushlike streamers. With decreasing resistivity, the branching of these streamers seemed to increase.

**21521.** Shaviv, G.; Salpeter, E. E. Gas dynamics of flow past galaxies, *Astron. Astrophys.* 110, 300-315 (1982).

Key words: clusters of galaxies; evolution of galaxies; galaxies; intergalactic matter.

Gas dynamic calculations are carried out numerically for a (spherical) galaxy with gas emission moving through intergalactic gas, separately for nonviscous flow and for overestimated transport coefficients. We find: a) For nonviscous cases the ram pressure stripping is never complete and Bremsstrahlung cooling induces an



instability on a relatively short timescale. b) Viscous dissipation and heat conduction by the plasma can prevent the instability and give rise to a steady state in which all the mass produced inside the galaxy is stripped away, irrespective of the flow conditions. c) Mass-loss occurs mostly via the tail. The temperature in the tail is lower than the temperature of the cluster gas. Bow shock is negligible. The rate of stripping depends on momentum flow. d) The form and viscous drag coefficients are of the order of 0.1 and hence cannot be neglected in cluster evolution. The gravitational drag is however very small.

**21522.** Norcross, D. W. Recent developments in the theory of electron collisions with polar molecules, *Proc. Daresbury Study Week-end, Daresbury Laboratory, Daresbury, Warrington, England, Mar. 26-27, 1982*, pp. 64-69 (Science and Engineering Research Council, Daresbury Laboratory, Daresbury, England, 1982).

Key words: collision theory; electron molecule collisions; polar molecules.

This paper discusses recent advances in theory that have occurred on several fronts: in applications and extensions of perturbation theory, semiclassical methods, and the adiabatic-nuclei approximation; in the development of more realistic and complete representations of the interaction at short as well as long range; in computational techniques for carrying out ever more elaborate and precise calculations; and in the application of these advances to more complicated collision processes such as vibrational excitation.

**21523.** O'Connell, J. S. Neutrino reactions on the deuteron, *Proc. Los Alamos Neutrino Workshop, Los Alamos, NM, June 8-12, 1981*, pp. 43-47 (Los Alamos National Laboratory, Los Alamos, NM 87545, Aug. 1982).

Key words: cross section; deuteron; electron; muon; neutrino; weak interaction.

The differential and total cross sections for the production of electrons and muon from deuterium by neutrinos up to 300 MeV is calculated using a simple wave function for the deuteron.

**21524.** O'Connell, J. S. Neutrino reactions in the Fermi gas model, *Proc. Los Alamos Neutrino Workshop, Los Alamos, NM, June 8-12, 1981*, pp. 37-42 (Los Alamos National Laboratory, Los Alamos, NM 87545, Aug. 1982).

Key words: cross section; electron; Fermi gas; muon; neutrino; weak interaction.

The differential and total cross sections for the production of electrons and muons from nuclei by neutrinos up to 300 MeV is calculated using the Fermi gas model of the nucleus.

**21525.** White V, E.; Welch, M. J.; Sun, T.; Sniegoski, L. T.; Schaffer, R.; Hertz, H. S.; Cohen, A. The accurate determination of serum glucose by isotope dilution mass spectrometry—Two methods, *Biomed. Mass Spectrom.* 9, No. 9, 395-405 (1982).

Key words: definitive method; gas chromatography/mass spectrometry; glucose; glucose- $U^{13}C$ ; human serum; isotope dilution; quantitation by bracketing.

Two isotope dilution mass spectrometric methods have been developed for the determination of D-glucose in human serum. Each uses a uniformly labeled ( $^{13}C$ ) glucose as the internal standard. The first method involves conversion of glucose into 1,2:5,6-di-O-isopropylidene- $\alpha$ -D-glucopyranose and an extensive clean-up, followed by quantitation using packed column gas chromatography mass spectrometry. In the second method, glucose is converted into  $\alpha$ -D-glucopyranose cyclic 1,2:3,5-bis(butylboronate)-6-acetate. The wet chemistry work-up is simpler, but analysis by capillary gas chromatography mass spectrometry is required. Both methods exhibit excellent precision (coefficients of variation  $<0.3\%$ ) and provided mean values that agree within 1% for all serum pools tested.

**21526.** Reilly, M. L.; Churney, K. L.; Kirklin, D. R.; Ledford, A. E.; Domalski, E. S. An oxygen flow calorimeter for kilogram-size samples of municipal solid waste. Part I. A 25 gram capacity combustion flow calorimeter for determining the calorific value of refuse-derived fuels, *Resources Conserv.* 8, 147-157 (1982).

Key words: higher heating value; oxygen flow calorimetry; refuse-derived fuel; sample characterization; 25 gram flow calorimetry.

A new calorimeter is under development at the National Bureau of Standards to determine the enthalpies of combustion of kilogram-size samples of minimally processed municipal solid waste (MSW) in flowing oxygen near atmospheric pressure. A small prototype calorimeter is described in which the organic fraction of 25 g pellets of highly processed MSW has been burned in pure oxygen to  $CO_2$  and  $H_2O$ . The basic measurement equation used to calculate the enthalpy of combustion from the observed data is discussed. An error analysis is presented. The results obtained with the prototype calorimeter are shown to agree with those obtained with bomb calorimetry within their respective overall uncertainties. Pure cellulose was found to be a satisfactory chemical calibrant material.

**21527.** Newbury, D. E. What is causing failures of aluminum wire connections in residential circuits?, *Anal. Chem.*, pp. 1059A-1064A (Aug. 1982).

Key words: aluminum wire; electron probe microanalysis; glow failures; resistive junctions; scanning electron microscopy; x-ray microanalysis.

Scanning electron microscopy and electron probe x-ray microanalysis have been applied to the analysis of structures produced during glow failures of aluminum wire connections in household duplex electrical outlets. Model wire/screw systems and actual residential connections tested to failure in the laboratory have been studied by analyzing free surfaces of wires and metallographic cross sections through the components of interest. Intermetallic compounds such as  $Fe_3Al$  and  $CuAl_2$  are found to form at the current-carrying interfaces between the aluminum wire and steel screw and between the aluminum wire and brass plate. Intermetallic compounds have significantly higher resistivity than the pure metals and can provide sufficient resistance to lead to the generation of heat by  $I^2R$  losses.

**21528.** Dolson, D. A.; Leone, S. R. Slow chain reactions of  $Br_2$  and  $Cl_2$  with HI: Multiple state analysis and vibrational relaxation of  $HBr(v=2)$  and  $HCl(v=1-4)$ , *J. Chem. Phys.* 77, No. 7, 4009-4021 (Oct. 15, 1982).

Key words: chain reaction; energy transfer; infrared emission; laser; laser chemistry; vibrational; vibrational relaxation.

Two chain reactions of the general form  $X + HI \rightarrow HX(v \leq v_{max}) + I$ ,  $I + X_2 \rightarrow IX + X$  ( $X = Br, Cl$ ) are studied by realtime detection of infrared chemiluminescence from the vibrationally excited  $HX(v)$  products. Both are characterized by  $k_2 \ll k_1$ . These reactions are initiated by pulsed UV laser photolysis of the diatomic halogens at 355 nm in a flow cell apparatus at 295 K. Observations are made on  $\Delta v = -1$  fluorescence from individual vibrational levels, and the results are treated with a complete mathematical analysis for the production of multiple vibrational states and their subsequent individual decays. Effects of vibrational cascading on the measurements of  $k_2$  are discussed. The chain propagation rate coefficients determined by this technique for  $k_1$  ( $X = Br, Cl$ ) and  $k_2$  ( $X = Br, Cl$ ) are  $8.9(\pm 1.3) \times 10^{-12}$ ,  $1.4(\pm 0.3) \times 10^{-10}$ ,  $3.4(\pm 0.8) \times 10^{-13}$ , and  $8.5(\pm 1.1) \times 10^{-17}$   $cm^3$  molecule $^{-1}$  s $^{-1}$ , respectively. The deactivation rate coefficients for  $HBr(v=2)$  and  $HCl(v=1,2,3,4)$  by HI are  $1.7(\pm 0.2) \times 10^{-12}$ ,  $1.43(\pm 0.05) \times 10^{-13}$ ,  $6.3(\pm 0.5) \times 10^{-13}$ ,  $7.0(\pm 2.4) \times 10^{-13}$ , and  $3.2(\pm 0.7) \times 10^{-12}$   $cm^3$  molecule $^{-1}$  s $^{-1}$ , respectively. Vibrational deactivation rate coefficients for  $HCl(v=1,2,3,4)$  by  $Cl_2$  are  $5.2(\pm 0.3) \times 10^{-15}$ ,  $2.2(\pm 0.3) \times 10^{-14}$ ,  $4.3(\pm 4.2) \times 10^{-14}$ , and  $2.8(\pm 1.5) \times 10^{-13}$   $cm^3$  molecule $^{-1}$  s $^{-1}$ , respectively. The vibrational deactivation efficiencies of  $HCl(v=1-4)$  by HI and  $Cl_2$  scale approximately at  $v^n$ , where  $n = 2.1(\pm 0.2)$  and  $2.8(\pm 0.2)$ , respectively.

**21529.** Boland, W.; De Jong, T. Carbon depletion in turbulent molecular cloud cores, *Astrophys. J.* 261, No. 1, 110-114 (Oct. 1, 1982).

Key words: interstellar, abundances; interstellar, molecules; turbulence.

Observations of dense molecular cores indicate that about 10% of the carbon is still in the gas phase (depletion factor  $\sim 0.1$ ) in spite of the fact that the depletion time—the time needed for heavy elements to freeze out on dust grains—is several orders of magnitude smaller



than the cloud lifetime. To resolve this problem, we suggest that the material in molecular cloud cores is circulated by turbulence and that every time a parcel of gas and dust reaches the outer layers of the core, dust mantles that have formed by accretion in the center are evaporated and/or photodesorbed. The observed mild degree of depletion results because the circulation time and the depletion time are of the same order of magnitude. Since the time to reach molecular equilibrium in the outer layers of a cloud core is short compared with  $t_{\text{circ}}$ , the dust plays no role in the chemistry. In the center of a cloud core, the time to convert C to CO is of order  $t_{\text{circ}}$ , so that an appreciable fraction of the gaseous carbon remains in atomic form. From a brief discussion of the energetics, we conclude that the turbulence observed in molecular cloud cores can be maintained during the lifetime of the cloud if the envelope collapses onto the core at a rate of about  $10^{-6} M_{\odot} \text{ yr}^{-1}$ .

**21530.** Blau, P. J. Test of a rule of mixtures for dry sliding friction of 52100 steel on an Al-Si-Cu alloy, *Wear* 81, 187-192 (1982).

Key words: aluminum alloys; friction; metal-matrix composites; mixtures rule; running-in; silicon.

Friction coefficient data were obtained for dry sliding of a fixed 52100 steel ball on flats of Si, 2024-T4 Aluminum alloy, and C390-T5 Aluminum alloy using a computer controlled, linear, stroke-by-stroke tribometer. Two surface finishes on the C390-T5 alloy were compared: 1) polished, 2) deeply etched to allow the Si phase to stand above the matrix Al-phases. Friction results for the C390-T5 alloy were compared with those of Si and 2024-T4 alloy to see if a friction rule of mixtures would be obeyed. Results for the polished surface of C390-T5 showed better agreement in friction coefficient between experimental and calculated values after an initial (running-in) period than did the etched surface ( $\pm 0.02$  in friction coefficient for the polished surface and  $\pm 0.06$  in friction coefficient for the etched surface). However, the initial stroke-by-stroke friction variations for the etched surface compared more favorably to those predicted by the assumed mixture rule, than did the variations observed for the polished surface.

**21531.** DeRossi, D.; DeReggi, A. S.; Broadhurst, M. G.; Roth, S. C.; Davis, G. T. Method of evaluating the thermal stability of the pyroelectric properties of polyvinylidene fluoride: Effects of poling temperature and field, *J. Appl. Phys.* 53, No. 10, 6520-6525 (Oct. 1982).

Key words: piezoelectric; polymer; polyvinylidene fluoride; pyroelectric; thermal stability.

The ac pyroelectric response of a number of differently poled polyvinylidene fluoride films has been measured while the temperature was varied at a constant rate  $\sim 5^{\circ}\text{C}/\text{min}$  from room temperature to near the melting temperature. The response first increases with increasing temperature, which is attributed to an increase of the thermal expansion coefficient and eventually decreases due to melting and/or loss of electric dipole orientation. The details of the temperature dependence are influenced in a reproducible manner by the poling variables, especially the poling temperature. The measurement is therefore proposed as a way of evaluating the effect of processing variables on the thermal stability of the pyroelectric properties.

**21532.** Ledford, A. E.; Ryan, R. V.; Reilly, M. L.; Domalski, E. S.; Churney, K. L. An oxygen flow calorimeter for kilogram-size samples of municipal solid waste. Part II. Trial combustions of kilogram-size samples, *Resources Conserv.* 8, 159-165 (1982).

Key words: combustor; municipal solid waste; oxygen combustion; refuse derived fuel.

A new calorimeter is being developed at the National Bureau of Standards to determine the enthalpies of combustion of kilogram-size samples of municipal solid waste (MSW) in flowing oxygen near atmospheric pressure. Experiments were carried out to develop a prototype combustor in which pellets of relatively unprocessed MSW can be rapidly and completely burned with minimal scattering of ash. Pellets of up to 2.2 kg mass with ash contents between 20 and 35% have been successfully burned at a rate of 15 minutes per kilogram initial mass with  $\text{CO}/\text{CO}_2$  ratios not greater than 0.1%.

**21533.** Hughes, E. E. Certified Reference Materials for continuous emission monitoring, (Proc. APCA Specialty Meet. Continuous Emission Monitoring, Denver, CO, Nov. 12, 1981), *APCA J.* 32, No. 7, 708-711 (July 1982).

Key words: air pollution; Certified Reference Materials; emission monitoring; gas standards; nitrous oxide.

The Certified Reference Material Program for gaseous standards jointly developed by the National Bureau of Standards and the Environmental Protection Agency is intended to increase the supply of accurate gas standards for environment monitoring. The gaseous Certified Reference Materials (CRM) are gas mixtures prepared and analyzed by specialty gas manufacturers according to guidelines set forth by NBS and the EPA. Certified Reference Materials are prepared at concentrations within  $\pm 1\%$  relative of existing gaseous Standard Reference Materials (SRM) and are analyzed by comparison to SRM. Samples from each lot are analyzed by an independent laboratory to confirm the concentration claimed by the manufacturer. Analyses performed by the manufacturer at stated time intervals after preparation are used to confirm the stability of each sample and the homogeneity of each batch. All data obtained by the manufacturer and the independent laboratory are reviewed by NBS to assure the reliability of the product.

Experimental batches of CRM prepared by two different manufacturers have been evaluated. These CRM, 50 ppm of carbon monoxide in nitrogen, were found to be stable and homogeneous and the concentrations claimed by the manufacturer were confirmed by the independent laboratory. Data from these sets will be presented, demonstrating the rigorous treatment required of the manufacturer and the independent laboratories.

Future CRM will include nitric oxide in nitrogen, sulfur dioxide in nitrogen, and propane in air.

**21534.** Coyle, T. D. Silica, *Kirk-Othmer: Encycl. Chem. Technol.* Third Edition, 20, 748-766 (1982).

Key words: amorphous silica; chemical properties; silica; silicates; silicon dioxide; structure; vitreous silica.

This is an introduction to the section on Silica in the 3d edition of the Encyclopedia of Chemical Technology. This introductory material provides an elementary discussion of structure and bonding in silica and related systems. Structural aspects of the principal forms of crystalline and non-crystalline silica are presented. Chemical reactions of  $\text{SiO}_2$  are reviewed briefly. A brief summary of generic users is included.

**21535.** Wise, S. A.; Bowie, S. L.; Chesler, S. N.; Cuthrell, W. F.; May, W. E.; Rebbert, R. E. Analytical methods for the determination of polycyclic aromatic hydrocarbons on air particulate matter, *Proc. Polynuclear Aromatic Hydrocarbons: Sixth Int. Symp. Physical and Biological Chemistry, Columbus, OH, Oct. 26-29, 1981*, pp. 919-929 (Battelle Press, 505 King Avenue, Columbus, OH 43201, 1982).

Key words: air particulate matter; fluorescence detection; gas chromatography (GC); liquid chromatography (LC); normal-phase LC; polycyclic aromatic hydrocarbons; reversed-phase LC; standard reference material (SRM).

Analytical methods for the determination of polycyclic aromatic hydrocarbons (PAH) on urban air particulate matter are described. These methods consist of extraction, isolation of PAH by normal-phase liquid chromatography (LC) followed by analysis by gas chromatography (GC) and reversed-phase LC. Quantitative results obtained by GC and LC for an air particulate material, which will be issued as a Standard Reference Material, are compared.

**21536.** Maximon, L. C. A method for making Coulomb effect corrections to reaction amplitudes, *Department of Physics Technical Report GWU/DP/TR-82/2*, 93 pages (George Washington University, Department of Physics, Washington, DC 20052, 1982).

Key words: Coulomb amplitudes; Coulomb wave functions; final state rescattering; integral representations; integral transforms; partial wave rescattering amplitudes.

We develop a method whereby the  $l$ -th partial wave rescattering



amplitude including the Coulomb interaction in the final state can be obtained from the  $l$ -th partial-wave rescattering amplitude without the Coulomb interaction by folding the latter with an analytically known kernel function. This function depends on the relative momentum of the particles involved and on their Coulomb parameter. A simplified expression for this kernel is given in first Born approximation.

**21537.** Garroway, A. N.; VanderHart, D. L.; Earl, W. L.  $^{13}\text{C}$  n.m.r. in organic solids: Limits to spectral resolution and to determination of molecular motion, *Philos. Trans. R. London Ser. A* **299**, 609-628 (1981).

Key words: carbon 13; molecular motion; nuclear magnetic resonance; organic solids; resolution; solids.

The history of high-resolution n.m.r. in solids has been, *inter alia*, a quest for narrow spectral lines. Yet, with few exceptions, solid state resonances have not been sharpened to the degree of liquid resonances. To aid in the appraisal of the status of n.m.r. in solids, we identify and summarize, for the particular case of  $^{13}\text{C}$  n.m.r. in organic solids, those effects that can degrade resolution. Some of these mechanisms are under the experimenter's control; for example, certain are exacerbated at high magnetic field. Others, however, represent fundamental limitations imposed by the specimen and are valid reflections of the complexity of a solid as contrasted to a liquid.

In solids, magnetic dipolar spin-spin couplings can not only degrade resolution but also complicate, hopelessly in some cases, the determination of spin-lattice relaxation rates from which one seeks information about molecular motions. The consequences of this competition between spin-spin and spin-lattice effects are examined, as well as criteria and strategies to isolate the motional contributions to relaxation rates.

**21538.** Soulen, R. J., Jr.; Van Vechten, D. Noise thermometry at NBS using a Josephson junction, (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., V, 115-123 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: Josephson effect; noise thermometer; Nyquist equation; superconducting fixed points; thermodynamic temperature.

We have been measuring the Johnson noise generated by a resistor using a Josephson junction. From these measurements we have developed a temperature scale extending from 0.01 to 0.52 K. The estimated inaccuracy at the lower end is  $\pm 0.5\%$ ; at the higher end it is reduced to  $\pm 0.2\%$ . These estimates are based in part on comparisons with a  $\gamma$ -ray anisotropy thermometer from 0.01 to 0.05 K and with a paramagnetic salt from 0.03 to 0.52 K. We also describe how extraneous noise sources may be detected and suppressed.

**21539.** Mehlman, G.; Cooper, J. W.; Saloman, E. B. Absolute photoabsorption cross section of the  $K$  shell of atomic lithium, *Phys. Rev. A* **25**, No. 4, 2113-2122 (Apr. 1982).

Key words: cross section; photoionization; resonances.

The absolute cross section of atomic lithium has been measured in the spectral range from 175 to 110 Å thus extending previous work to shorter wavelengths. Good agreement is found with theoretical predictions. The autoionizing-resonant-structure excitation between 176 and 160 Å has been measured and line-profile parameters obtained for several of the resonances. The resonant structure for core excitation associated with  $N=3$  and  $N=4$  principal quantum numbers is found to bear a close relationship to the analogous excitations in helium. A new classification of the resonant structure is given and comparisons made with theoretical results. A discussion of the total oscillator strength for  $K$ -shell excitation in lithium is given and the results obtained from the present and previous work are compared with the Thomas-Reiche-Kuhn sum-rule value.

**21540.** Sugar, J.; Kaufman, V.; Cooper, D. C I isoelectronic sequence: Observations of  $2s^m 2p^n - 2s^{m-1} 2p^{n+1}$  intersystem transitions and improved measurements for Cl XII, K XIV, Ca XV, Sc XVI, Ti XVII, and V XVIII, *Phys. Scr.* **26**, No. 3, 189-193 (1982).

Key words: Ca XV; Cl XII; energy levels; K XIV; Sc XVI;

spectra; Ti XVII; V XVIII.

Spectra of Cl through V (excluding Ar) were produced with a 1 GW (15 ns) pulse from a Nd-glass laser impinging on solid targets and observed with a 10.7-m grazing incidence spectrograph. Strong  $2s^m 2p^n - 2s^{m-1} 2p^{n+1}$  transition arrays in the C I isoelectronic sequence were recorded, from which intersystem lines were identified and improved wavelength measurements of allowed lines were made. Hartree-Fock calculations of the radial integrals were compared with those obtained from least squares fits of the energy levels of this sequence.

**21541.** Clough, R. B.; Wadley, H. N. G. Indentation loading studies of acoustic emission from temper and hydrogen embrittled A533B steel, *Metall. Trans. A*, **13A**, 1965-1975 (Nov. 1982).

Key words: acoustic emission; A533B; fracture; hydrogen embrittlement; pressure vessel steel; temper embrittlement.

Isothermal tempering at 500°C (within the region rendering low alloy steels susceptible to reversible temper embrittlement) induced acoustic emission activity in A533B steel during indentation loading. Samples, when sectioned, were found to contain small ( $\sim 10\ \mu\text{m}$  long) MnS inclusions, some of which had debonded from the matrix material when they were near the indentations. Hydrogen charging prior to testing greatly enhanced the acoustic emission activity. It also resulted in the formation of small ( $\sim 20$  to  $200\ \mu\text{m}$ ) microcracks in samples tempered at 500°C. These microcracks, when examined by optical metallography, appear to have propagated along prior austenite grain boundaries, consistent with fractographic observations of temper embrittlement in other low alloy steels. Many were nucleated by MnS inclusion debonding and all were confined to within a few hundred micrometers of the sample surface and within two or three indenter diameters from the indent. It is proposed that trace impurities (P, As, Sb, Sn) diffuse during the 500°C temper to both the MnS inclusion interfaces and the prior austenite grain boundaries, reducing local cohesive strength. The tensile field created by the indenter debonds inclusions to form crack nuclei. Moderate acoustic emission results. In the absence of hydrogen these void nuclei may grow but do not coalesce to form observable cracks. The prior austenite grain boundaries, which in contrast to the dispersed inclusions can provide continuous crack paths, are not sufficiently temper embrittled to fracture without the assistance of hydrogen at these stresses. Hydrogen charging induces a high hydrogen concentration in a surface layer of the sample. This reduces further the grain boundary cohesion, and cracks initiated at inclusions are able to propagate along continuous grain boundary paths, generating additional energetic acoustic emission signals. This process can continue after unloading the indenter due to hydrogen diffusion to the residual stress field.



## 7. LISTING OF NBS PAPERS BY MAJOR SUBJECT AREAS

This section provides a listing of papers organized by primary subject matter as follows:

Acoustics and Sound  
Analytical Chemistry  
Atomic and Molecular Studies  
Building Technology  
Computer Science and Technology  
Consumer Information and Protection  
Electromagnetic Metrology  
Electronic Technology  
Energy Conservation and Production  
Engineering, Product and Information Standards  
Environmental Studies: Pollution Measurement  
Failure Analysis  
Fire Research  
Fluids: Liquids, Gases and Plasmas  
General Theoretical Chemistry and Physics  
Health and Safety  
Instrumentation and Experimental Methods  
Lasers and Their Applications  
Low Temperature Science and Engineering  
Mathematical and Statistical Methods  
Measurement Science and Technology:  
    Policy and State-of-the-Art Surveys  
Measurement Science and Technology:  
    Physical Standards and Fundamental Constants  
Mechanics: Design, Testing and Measurement  
Metrology: Physical Measurements

Nuclear Physics and Radiation Technology  
Operations Analysis and Applications  
Processing and Performance of Materials  
Properties of Materials: Electronic, Magnetic and Optical  
Properties of Materials: Structural and Mechanical  
Properties of Materials: Thermodynamic and Transport  
Standard Reference Data  
Standard Reference Materials  
Surfaces and Interfaces  
Thermodynamics and Chemical Kinetics  
Technology Incentives  
Other Subjects of General Interest

It permits users of this catalog to scan the Bureau's output by major subject category. The user should bear in mind that a paper is listed once by major subject even though it might well contain other secondary subject matters of interest. The key word index permits the reader to determine the overall context of a paper, and provides an excellent secondary reference source.

The categories currently in use for classifying NBS publications are listed below and are followed by a listing of each paper by category. Full citations (including key words and abstracts) will be found under the appropriate publication series, which is included in the paper title. Also of use will be the key word index (mentioned above) and the author index.



## Acoustics and Sound

- NBSIR 82-2529. Greenspan, M.; Eitzen, D. G. Ultrasonic research—Summary report and literature guide to the National Bureau of Standards/Office of Naval Research Program, 1982 June. 11 p. Available from: NTIS; PB 82-229345.
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 Abelson, D. S.; *SP632*; 1982 March. 40-42.  
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 Agarwal, G. S.; Ananthalakshmi, P.; *21320*.  
 Agarwal, G. S.; Haan, S. L.; Burnett, K.; Cooper, J.; *21281*.  
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 Allan, D. W.; Barnes, J. A.; *21284*.  
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Babrauskas, V.; *21094*.  
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 Babrauskas, V.; *21092*.  
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Mehl, J. B.; Moldover, M. R.; 21208.  
Mehl, J. B.; Moldover, M. R.; 21230.  
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Mehrabian, R.; Cohen, M.; Kear, B. H.; 21090.  
Meier, M. M.; Duvall, K. C.; Wasson, O. A.; 21135.  
Meier, M. M.; Wasson, O. A.; 20814.  
Meijer, P. H. E.; Wong, Y. M.; 21399.  
Melmed, A. J.; Carroll, J. J.; 21021.  
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 Wainwright, A. E.; Reeve, G. R.; 20892.  
 Wakamatsu, T.; Morishita, Y.; SP639; 1982 September. 17-21.  
 Waksman, D.; Streed, E. R.; Thomas, W. C.; Dawson, A. G., III; 21387.  
 Waksman, D.; Walton, W. D.; 21134.  
 Waksman, D.; Walton, W. D.; NBSIR 81-2344.  
 Walcheski, A. F.; White, M. L.; SP400-72; 1982 April. 76-78.  
 Waldman, P.; NBS-GCR-82-383; 1982 March. 64-65.  
 Walker, J. S.; Lee, R. J.; Kelly, J. F.; SP619; 1982 March. 132-137.  
 Walker, W. R.; SP624; 1982 June. 17-26.  
 Wallace, W. E.; Hardman, K.; Rhyne, J. J.; Malik, S.; 20944.  
 Wallace, B.; Proppe, M.; SP500-95; 1982 October. 409-413.  
 Walls, D. F.; Drummond, P. D.; McNeil, K. J.; 20918.

- Walls, F. L.; 20934.  
 Walls, F. L.; Feldman, M.; Bergquist, J. C.; Lewis, L. L.; 21203.  
 Walls, F. L.; Glaze, D. J.; Lewis, L. L.; 21251.  
 Walls, F. L.; Howe, D. A.; 21192.  
 Walls, F. L.; Wineland, D. J.; Bergquist, J. C.; Drullinger, R. E.; Hemmati, H.; Itano, W. M.; 21191.  
 Walls, F. L.; Wineland, D. J.; Itano, W. M.; Bergquist, J. C.; 21202.  
 Walton, D.; Metz, F. E.; Pielert, J. H.; Cooke, P. W.; NBSIR 82-2554.  
 Walton, D.; Quintiere, J.; Harkleroad, M.; NBSIR 82-2557.  
 Walton, G. N.; 21123.  
 Walton, W. D.; Waksman, D.; 21134.  
 Walton, W. D.; Waksman, D.; NBSIR 81-2344.  
 Wan, C. A.; Palla, R. L., Jr.; Harris, J. E.; NBSIR 81-2372.  
 Wang, C. C.; Villarruel, C. A.; Burns, W. K.; SP641; 1982 October. 97-100.  
 Wang, G. C.; Celotta, R. J.; McRae, E. G.; Pierce, D. T.; 20976.  
 Wang, G. C.; Unguris, J.; Pierce, D. T.; Celotta, R. J.; 20865.  
 Ward, J. F.; Popenoe, C. H.; Green, A. E. S.; Kostkowski, H. J.; Saunders, R. D.; TN910-5.  
 Warnlof, O. K.; H44.  
 Wasik, S. P.; Tewari, Y. B.; Miller, M. M.; J. Res. 87(2): 155-158; 1982 March-April.  
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 Wasson, O. A.; Carlson, A. D.; Duvall, K. C.; 20861.  
 Wasson, O. A.; Meier, M. M.; 20814.  
 Wasson, O. A.; Meier, M. M.; Duvall, K. C.; 21135.  
 Wasson, O. A.; Schrack, R. A.; Behrens, J. W.; Johnson, R. G.; Duvall, K. C.; Bowman, C. D.; Carlson, A. D.; 21022.  
 Waters, F.; SP632; 1982 March. 59-60.  
 Waterstrat, R. M.; Paffenbarger, G. C.; Rupp, N. W.; 20850.  
 Watson, R. E.; Swartzendruber, L. J.; Bennett, L. H.; 20820.  
 Watson, R. T.; Baulch, D. L.; Cox, R. A.; Crutzen, P. J.; Hampson, R. F., Jr.; Kerr, J. A.; Troe, J.; JPCRD 11(2): 327-496; 1982.  
 Waxler, R. M.; Feldman, A.; 21085.  
 Way, J. D.; Flynn, T. M.; 21241.  
 Weaver, M. A.; SP629; 1982 January. 31-33.  
 Webbink, R. F.; Rappaport, S.; Joss, P. C.; 21010.  
 Weber, A.; 21300.  
 Weber, J.; NBS-GCR-82-383; 1982 March. 62-63.  
 Weber, L. A.; 21187.  
 Weber, S. F.; Lippiatt, B. C.; 21142.  
 Weber, S. F.; Lippiatt, B. C.; Hillstrom, A. P.; SP624; 1982 June. 227-238.  
 Wechsler, H.; Salomone, L. A.; Kovacs, W. D.; BSS149.  
 Weeks, S. J.; Hsu, S. M.; Clark, D. B.; NBSIR 82-2490.  
 Weglein, R. D.; Wilson, R. G.; NBS-GCR-81-363.  
 Weglein, R. D.; Wilson, R. G.; NBS-GCR-82-401.  
 Wegstein, J. H.; SP500-89.  
 Weidner, V. R.; Hsia, J. J.; SP260-75.  
 Weidner, V. R.; Wilmering, D. B.; Richmond, J. C.; Hsia, J. J.; SP260-79.  
 Weinberg, W. H.; Yates, J. T., Jr.; Williams, E. D.; 20962.  
 Weiss, A. W.; Detrich, J.; 21057.  
 Weiss, G. H.; Rubin, R. J.; 20826.  
 Weiss, M.; Clements, A.; Allan, D. W.; Davis, D. D.; 21204.  
 Weisshaar, J. C.; Zwier, T. S.; Leone, S. R.; 20784.  
 Welch, M. J.; White, V. E.; Cohen, A.; Hertz, H. S.; Mandel, J.; Paule, R. C.; Svensson, L.; Björkhem, I.; Blomstrand, R.; Schaffer, R.; Sniegowski, L. T.; 20796.  
 Wellisch, H. H.; SP500-94; 1982 October. 215-218.  
 Wells, J. S.; McDowell, R. S.; Patterson, C. W.; Nereson, N. G.; Petersen, F. R.; 21216.  
 Wenzel, J. T.; Sanders, D. M.; 21108.  
 Werth, J.; Sherman, S.; NBS-GCR-82-393.  
 Wesely, E. F., Jr.; Yeaman, B.; SP624; 1982 June. 69-80.  
 West, E. D.; Dittmars, D. A.; Ishihara, S.; Chang, S. S.; Bernstein, G.; J. Res. 87(2): 159-163; 1982 March-April.  
 West, J. B.; Codling, K.; Ederer, D. L.; Parr, A. C.; Cole, B. E.; Stockbauer, R.; Dehmer, J. L.; 20870.  
 West, J. B.; Holland, D.; Dehmer, J. L.; Ederer, D. L.; Parr, A. C.; 21291.  
 West, J. B.; Holland, D. M. P.; Dehmer, J. L.; Parr, A. C.; Ederer, D. L.; 21006.  
 West, J. B.; Holland, D. M. P.; Parr, A. C.; Ederer, D. L.; Dehmer, J. L.; 21112.  
 Westley, F.; SP630.



- Westley, F.; *NSRDS-NBS72*.
- Whitaker, B.; *SP632*; 1982 March. 24-27.
- White, D. J.; Slotter, L. E.; Shawver, W. R.; *SP640*; 1982 October. 45-60.
- White, J. C.; Schaffer, R.; Velapoldi, R. A.; Paule, R. C.; Mandel, J.; Bowers, G. N., Jr.; Copeland, B. E.; Rodgerson, D. O.; *21206*.
- White, M. L.; Sammons, R. E.; *SP400-72*; 1982 April. 49-63.
- White, M. L.; Walcheski, A. F.; *SP400-72*; 1982 April. 76-78.
- Whitehill, D.; Winter, A.; Alsager, P.; Deline, M.; Hall, J.; McGrath, W.; Strader, R.; DenUyl, R. B.; VanPoperin, N.; *NBS-GCR-82-405*.
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- Whiting, E. E.; Schadee, A.; Tatum, J. B.; Hougen, J. T.; Nicholls, R. W.; *21274*.
- Wiederhorn, S. M.; Freiman, S. W.; Fuller, E. R., Jr.; Simmons, C. J.; *NBSIR 82-2524*.
- Wiederhorn, S. M.; Tighe, N. J.; *NBSIR 81-2445*.
- Wiese, W. L.; Konjevic, N.; *21365*.
- Wilborn, D. P.; *SP624*; 1982 June. 47-51.
- Wilder, J. J.; *SP624*; 1982 June. 339-346.
- Wilkinson, G. M.; Katzenstein, J.; Caton, W.; *SP628*; 1982 June. 277-288.
- Wilkinson, M.; Chu, E.; *SP628*; 1982 June. 59-68.
- Wilkinson, M.; Richardson, R.; Chu, E.; Clark, W.; Shannon, J.; *SP628*; 1982 June. 150-164.
- Wilkinson, M.; Trivelpiece, C.; Shannon, J.; Chu, E.; Richardson, R.; *SP628*; 1982 June. 289-299.
- Willard, W. A.; Shives, T. R.; *SP621*.
- Willard, W. A.; Shives, T. R.; *SP640*.
- Williams, E. D.; Weinberg, W. H.; Yates, J. T., Jr.; *20962*.
- Williams, E. E.; Uribe, R. M.; McLaughlin, W. L.; Miller, A.; Dunn, T. S.; *20905*.
- Williams, E. S.; *TN1166*.
- Williams, F. E.; Barton, D. R.; Friedman, D. B.; Post, H. A.; *NBS-GCR-82-371*.
- Williams, R. T.; Rife, J. C.; Nagel, D. J.; Peckerar, M. C.; Hughey, L. R.; *21078*.
- Williams, S. S.; Krasny, J. F.; Damant, G. H.; *21128*.
- Williamson, C. F.; Maruyama, X. K.; Petrovich, F.; Lindgren, R. A.; Plum, M. A.; Gerace, W. J.; Hicks, R. S.; Parker, B.; Peterson, G. A.; Singhal, R.; *20797*.
- Wilmer, M. E.; Pearson, P. A.; *SP628*; 1982 June. 194-203.
- Wilmering, D. B.; Richmond, J. C.; Hsia, J. J.; Weidner, V. R.; *SP260-79*.
- Wilson, C. B.; *SP500-95*.
- Wilson, C. B.; Chan, P. M. C.; Mohr, J. M.; *NBS-GCR-82-382*.
- Wilson, C. L.; Blue, J. L.; *20823*.
- Wilson, C. L.; Blue, J. L.; *NBSIR 82-2471*.
- Wilson, C. L.; Lowney, J. R.; Kahn, A. H.; Blue, J. L.; *20830*.
- Wilson, P. F.; Chang, D. C.; Ma, M. T.; *TN1054*.
- Wilson, R.; *NBS-GCR-82-383*; 1982 March. 39-45.
- Wilson, R. G.; Jamba, D. M.; *SP400-71*.
- Wilson, R. G.; Myers, D. R.; Comas, J.; *20824*.
- Wilson, R. G.; Weglein, R. D.; *NBS-GCR-81-363*.
- Wilson, R. G.; Weglein, R. D.; *NBS-GCR-82-401*.
- Wineland, D. J.; *21285*.
- Wineland, D. J.; Bergquist, J. C.; Drullinger, R. E.; Hemmati, H.; Itano, W. M.; Walls, F. L.; *21191*.
- Wineland, D. J.; Itano, W. M.; *21011*.
- Wineland, D. J.; Itano, W. M.; Bergquist, J. C.; Walls, F. L.; *21202*.
- Wineland, D. J.; Itano, W. M.; Lewis, L. L.; *21217*.
- Wineland, D. J.; Itano, W. M.; Lewis, L. L.; *21205*.
- Winkler, G. M. R.; Allan, D. W.; Alley, C. O.; Ashby, N.; Decher, R.; Vessot, R. F. C.; *21201*.
- Winn, B. D.; Downing, W. D., Jr.; Pruett, J. P.; *SP640*; 1982 October. 216-221.
- Winter, A.; Alsager, P.; Deline, M.; Hall, J.; McGrath, W.; Strader, R.; DenUyl, R. B.; VanPoperin, N.; Whitehill, D.; *NBS-GCR-82-405*.
- Wipf, H.; Magerl, A.; Shapiro, S. M.; Satija, S. K.; Thomlinson, W.; *20941*.
- Wise, S. A.; Sonnefeld, W. J.; Zoller, W. H.; May, W. E.; *20981*.
- Wise, S. A.; Zeisler, R. L.; Goldstein, G. M.; Harrison, S. A.; Gills, T. E.; Maienthal, E. J.; Rook, H. L.; *21126*.
- Wlodawer, A.; Bott, R.; Sjölin, L.; *20893*.
- Wlodawer, A.; Hendrickson, W. A.; *21136*.
- Wlodawer, A.; Komoriya, A.; Chaiken, I. M.; Taylor, H. C.; Richardson, D. C.; Richardson, J. S.; *20914*.
- Wlodawer, A.; Sjölin, L.; *20982*.
- Wlodawer, A.; Sjölin, L.; *21137*.
- Wollin, H. F.; Barbrow, L. E.; Heffernan, A. P.; *SP629*.
- Wong, A. A.; Hannan, T. L.; *SP500-94*; 1982 October. 36-39.
- Wong, C. P.; Maurer, D. E.; *SP400-72*; 1982 April. 275-280.
- Wong, J. S.; Moore, C. B.; *21371*.
- Wong, M.; *FIPS PUB 61-1*.
- Wong, Y. M.; Meijer, P. H. E.; *21399*.
- Wood, H. M.; *21265*.
- Wood, J. H.; *SP631*; 1982 May. 295-309.
- Wood, J. H.; Garland, T. M.; *SP631*; 1982 May. 420-431.
- Wood, T. D. S.; Todd, C. J.; Stern, J. R.; Payne, D. B.; *SP641*; 1982 October. 79-84.
- Woodgate, B. E.; Athay, R. G.; Bruner, E. C., Jr.; Rehse, R. A.; Tandberg-Hanssen, E. A.; Gebbie, K. B.; Hill, F.; Toomre, J.; November, L. J.; Simon, G. W.; Gurman, J. B.; Shine, R. A.; *21213*.
- Woodward, K. A.; Reed, R. P.; Kasen, M. B.; Shives, T. R.; Marshall, R. D.; Pfrang, E. O.; Leyendecker, E. V.; *BSS143*.
- Worchesky, T. L.; Maki, A. G.; Lafferty, W. J.; Sattler, J. P.; *20852*.
- Worden, S. P.; Giampapa, M. S.; Golub, L.; Rosner, R.; Vaiana, G. S.; Linsky, J. L.; *21405*.
- Workman, J. L.; Crawford, M. L.; *21062*.
- Wright, J. V.; Nelson, B. P.; *SP641*; 1982 October. 9-12.
- Wright, R. N.; *20896*.
- Wuilleumier, F.; Bizau, J. M.; Dhez, P.; Koch, P.; Ederer, D. L.; Le Gouët, J. L.; Picqué, J. L.; *21221*.
- Wuilleumier, F.; Krummacher, S.; Schmidt, V.; Ederer, D.; Larsen, P. K.; Van Bers, W. A. M.; Bizau, J. M.; *21069*.
- Wulpi, D. J.; *SP621*; 1982 October. 196-200.
- Wunderlich, B.; Gaur, U.; *JPCRD 11(2)*: 313-325; 1982.
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- Wyart, J. F.; Kaufman, V.; *20878*.

## Y

- Yamamoto, H.; Saito, J.; Oki, T.; *SP641*; 1982 October. 29-32.
- Yamashita, H.; Arp, V. D.; *NBSIR 82-1660*.
- Yamate, G.; Beard, M. E.; *SP619*; 1982 March. 183-189.
- Yamate, G.; Jones, D. R.; *SP619*; 1982 March. 77-84.
- Yancey, C. W. C.; Yokel, F. Y.; Chung, R. M.; Rankin, F. A.; *BSS142*.
- Yang, G. L.; Croarkin, M. C.; *J. Res. 87(6)*: 485-511; 1982 November-December.
- Yap, W. T.; Doane, L. M.; *21361*.
- Yap, W. T.; Durst, R. A.; *20837*.
- Yates, J. T., Jr.; *20825*.
- Yates, J. T., Jr.; Goodman, D. W.; *20863*.
- Yates, J. T., Jr.; Griffin, G. L.; *20971*.
- Yates, J. T., Jr.; Williams, E. D.; Weinberg, W. H.; *20962*.
- Yeaman, B.; Wesely, E. F., Jr.; *SP624*; 1982 June. 69-80.
- Yee, K. W.; *NBSIR 82-2590*.
- Yee, K. W.; Blomquist, D. S.; *20795*.
- Yin, L. I.; Trombka, J. I.; Schmadebeck, R. L.; Seltzer, S. M.; Bielefeld, M. J.; *21366*.
- Yokel, F. Y.; Chung, R. M.; Powell, D.; Dobry, R.; Ladd, R. S.; *BSS138*.
- Yokel, F. Y.; Chung, R. M.; Rankin, F. A.; Yancey, C. W. C.; *BSS142*.
- Yoo, K. C.; Roessler, B.; Armstrong, R. W.; Kuriyama, M.; *21353*.
- Yoshizawa, S.; Morita, M.; Fukuoaka, M.; Tsushima, H.; Hashizume, Y.; Nakamura, T.; Handa, T.; *SP639*; 1982 September. 308-364.
- Yost, J. A.; Fisher, D. L.; *SP624*; 1982 June. 91-102.
- You, H. Z.; Faeth, G. M.; *NBS-GCR-81-304*.
- Young, D.; Power, J.; Nunnally, W.; *SP628*; 1982 June. 46-53.
- Young, F. C.; *SP628*; 1982 June. 104-117.
- Young, M.; Danielson, B. L.; Day, G. W.; Franzen, D. L.; Kim, E. M.; *SP637, Volume 1*.
- Young, M.; Hanson, A. G.; Bloom, L. R.; Cherin, A. H.; Day, G. W.;



Gallawa, R. L.; Gray, E. M.; Kao, C.; Kapron, F. P.; Kawasaki, B. S.; Reitz, P.; *H140*.  
 Young, R. A.; Brown, W. E.; *21110*.  
 Young, T. R.; *SP632*; 1982 March. 81-91.  
 Young, T. R.; *SP632*; 1982 March. 28-35.  
 Young, V. R.; Gramlich, J. W.; Machlan, L. A.; Janghorbani, M.; *21374*.  
 Young, W. C.; Curtis, L.; Kaiser, P.; *SP641*; 1982 October. 123-126.  
 Younger, S. M.; *20869*.  
 Younger, S. M.; *20992*.  
 Younger, S. M.; *21367*.  
 Younger, S. M.; *J. Res. 87(1)*: 49-51; 1982 January-February.  
 Younglove, B. A.; *JPCR D 11(Suppl. 1)*: 354 pp.; 1982.  
 Younglove, B. A.; *TN1048*.  
 Yusa, S.; Kishitani, K.; Saito, F.; *SP639*; 1982 September. 72-87.

## Z

Zabel, H.; Magerl, A.; *20949*.  
 Zaffarano, R.; *SP631*; 1982 May. 411-419.  
 Zalewski, E. F.; Geist, J.; Gladden, W. K.; *21396*.  
 Zalewski, E. F.; Velapoldi, R. A.; Demas, J. N.; Bowman, W. D.; *21045*.  
 Zaveler, S. A.; *SP500-94*; 1982 October. 166-171.  
 Zeisler, R. L.; Goldstein, G. M.; Harrison, S. A.; Gills, T. E.; Maienthal, E. J.; Rook, H. L.; Wise, S. A.; *21126*.  
 Zelkowitz, M. V.; Lyle, J.; *20943*.  
 Zeren, L.; Gonzalez, R.; Berglund, L.; McNall, P. E.; Arens, E.; *21004*.  
 Ziegler, C.; Klibaner, R.; *SP500-95*; 1982 October. 173-182.  
 Zielinski, W. L., Jr.; Scanlan, R. A.; Miller, M. M.; *20965*.  
 Zile, R. H.; Hayes, W. D., Jr.; *NBSIR 82-2521*.  
 Zimmerman, J. E.; Sullivan, D. B.; *TN1049*.  
 Zoller, W. H.; May, W. E.; Wise, S. A.; Sonnefeld, W. J.; *20981*.  
 Zuiches, C.; Clarren, S.; Nalley, P.; *NBS-GCR-ETIP 82-99*.  
 Zukoski, E. E.; Kubota, T.; Cetegen, B. M.; *NBS-GCR-82-402*.  
 Zumberge, M. A.; Faller, J. E.; Guo, Y. G.; *21318*.  
 Zwier, T. S.; Leone, S. R.; Weisshaar, J. C.; *20784*.



## 8.2 KEY WORD INDEX

### A

- ab initio; electronic structure; multiconfiguration; photodissociation; self-consistent field theory; 21308.
- ab initio effective spin-orbit operators; effective potentials; spin-orbit coupling; 21338.
- ab initio effective spin-orbit operators; effective potentials; spin-orbit coupling; 21333.
- abrasive wear; antimony thioantimonate; extreme pressure and antiwear properties; greases; solid lubricant additive; *SP640*; 1982 October. 150-161.
- absolute; calibration; continuum; irradiance; plasma; rare-earth; 21016.
- absolute calibration; absolute quantum yield; actinometry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; transfer standard; 21045.
- absolute configuration; crystal structure; dimer; fungal pigment; metabolite of pathogenic fungi; single crystal x-ray diffraction; xanthomycin; 21313.
- absolute cross section; crossed beams; electron-ion collisions; excitation; Ga II; resonance line; 21317.
- absolute fission cross section; neutron detector; neutron flux monitor; neutron standards; U-235 fission cross section; 21135.
- absolute gravity; geodesy; geophysics; gravity; tectonics; 21318.
- absolute measurement; accelerometer calibration; angular vibration; interferometer; reciprocity calibration; torsional vibration; 20967.
- absolute neutron measurement; neutron calibration; neutron source; neutron spectroscopy; neutron spectrum; neutron time-of-flight; 21022.
- absolute quantum yield; actinometry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; transfer standard; absolute calibration; 21045.
- absolute ratios; atomic weight; Faraday constant; isotopic abundance; mass spectrometry; silica gel; silver; silver iodide; *J. Res. 87(1)*: 9-19; 1982 January-February.
- absolute ratios; atomic weight; isotopic abundances; strontium; *J. Res. 87(1)*: 1-8; 1982 January-February.
- absolute reflectance; aluminum mirrors; first-surface mirrors; specular reflectance; specular standards; standard mirrors; standard reference material; *SP260-75*.
- absorbed dose; adiabatic; calorimeter; polyethylene film; thermistor; water calorimeter; *U.S. Patent 4,312,224*.
- absorbed dose; calibration; electron beam; high energy; ionization chamber; photon beam; radiation therapy; 20894.
- absorbed dose; calorimeter; convection; heat defect; radiation chemistry; thermistor; water; *J. Res. 87(3)*: 211-235; 1982 May-June.
- absorbed dose; environment; radioactivity; radiopharmaceuticals; standards; traceability; 21355.
- absorbing points; lattice random walk; mean occupation time; polymer adsorption; probability of first return; restricted random walk; 20826.
- absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; *TN1150*.
- absorption; adsorption; dew point; hygrometer; kinetics; microelectronic package; moisture; moisture level; relative humidity; sorption thermodynamics; *SP400-72*; 1982 April. 184-200.
- absorption; composite resins; expansion; hardening shrinkage; hygroscopic expansion; polymerization; water sorption; 21052.
- absorption; CO<sub>2</sub> laser; decane; ignition; 21304.
- absorption; CO<sub>2</sub> laser; decomposition; ignition; polymethacrylate; radiation; surface temperature; wood; 20792.
- absorption; high temperature; hydrogen isocyanide; infrared; molecular structure; potential functions; spectroscopy; 20782.
- absorption; ignition; polymethylmethacrylate; radiation; red oak; surface temperature; 21305.
- absorption; ignition; radiation; solid fuel; 21314.
- absorption chillers; boiler performance; central utility plant; diesel engine performance; engine-generator efficiency; environmental impact; heat recovery; total energy system; *NBSIR 82-2474*.
- absorption chillers; boiler performance; diesel engine performance; engine-generator efficiency; integrated utility system; total energy systems-economic and engineering analysis; waste heat recovery; *NBSIR 82-2483*.
- absorption coefficient; black paint; deuterium lamp; silicon photodiode; specular reflectance; ultraviolet reflectance; 20989.
- absorption coefficient; collision-induced; far infrared spectra; hydrogen; hydrogen mixtures; rotational transitions; spectra; 21165.
- absorption coefficients; carbonyl sulphide; intensities; microwave transitions; rotational transitions; *JPCRD 11(1)*: 101-117; 1982.
- absorption spectrum; atomic masses; collision-induced absorption; concentration; correlation function; density; rare gas mixtures; spectral behavior; 21007.
- absorptive coatings; accelerated laboratory exposures; degradation; outdoor exposures; simulated stagnation exposure; solar energy; *NBSIR 82-2583*.
- abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; utility systems; *SP489, Supplement 1*.
- abstraction; ethane-d<sub>6</sub>; ethynyl radicals; rate constants; 20780.
- abstraction reactions; activation energies; bond-energy-bond-order; CN; ethynyl; radicals; 20781.
- abstracts; building technology; Center for Building Technology; key words; publications; *SP457-6*.
- abstracts, NBS publications; key words; publications, NBS; *SP305, Supplement 13*.
- AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; experimental melting curves; high pressure; high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries; *JPCRD 11(4)*: 1005-1064; 1982.
- accelerants; arson; decision analysis; fire investigations; firesetters; 21256.
- accelerated bathtub exposure cycle; performance criteria for restoration coatings; porcelain enamel restoration; restoration coatings; *NBSIR 82-2553*.
- accelerated laboratory exposures; degradation; outdoor exposures; simulated stagnation exposure; solar energy; absorptive coatings; *NBSIR 82-2583*.
- accelerated moisture testing; microenvironments; moisture related failures; temperature effects on surface water; *SP400-72*; 1982 April. 165-174.
- accelerated testing; crevice corrosion; electrochemical techniques; localized corrosion; localized corrosion mechanism; pitting; *NBSIR 82-2477*.
- accelerator mass spectrometry; atmospheric pollution; carbonaceous gases and particles; carbon cycle; chemical selectivity; climate; low-level counting; radiocarbon; 21041.
- accelerometer; inertial mass; piezoelectric polymer films; *U.S. Patent 4,315,433*.
- accelerometer calibration; angular vibration; interferometer; reciprocity calibration; torsional vibration; absolute measurement; 20967.
- acceptance probability; compliance sampling; dual acceptance criteria; mixed sampling plan; order statistics; statistical methods; *J. Res. 87(6)*: 485-511; 1982 November-December.
- acceptance testing; accreditation systems; history; International Laboratory Accreditation Conference; international testing; laboratory accreditation; *NBSIR 82-2523*.
- acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; portability; program inventory; RFP; statement of work; *SP500-90*.
- access control; CODASYL; database management system; DBMS; network data model; *NBS-GCR-82-370*.
- accessibility; barrier-free design; building accessibility; database analysis; *NBSIR 82-2567*.
- accordion-type oscillation; drawn polyethylene; gauche defect; Raman scattering; straight chain section; 20790.
- accountability tank; calibration; differential pressure; volume; volumetric test measures; water calibration; *TN1158*.
- accreditation; certification; functions; laboratory accreditation; product certification; system operation; *SP632*; 1982 March. 24-27.
- accreditation; general needs; historical; laboratory evaluation; *SP632*; 1982 March. 28-35.
- accreditation; ILAC; laboratories; national programs; *SP632*; 1982 March. 76-78.
- accreditation; laboratory; legal system; standards code; testing laboratories; *SP632*; 1982 March. 40-42.
- accreditation procedures; corporate; Corporate Standard Quality



System; individual; laboratory; *SP632*; 1982 March. 52-53.

accreditation systems; history; International Laboratory Accreditation Conference; international testing; laboratory accreditation; acceptance testing; *NBSIR 82-2523*.

accredited laboratories; laboratory accreditation process; laboratory accreditation programs; *SP636*.

accrediting agencies; laboratory; recognition; *SP632*; 1982 March. 81-91.

accrediting laboratories; international; NVLAP system; United States; *SP632*; 1982 March. 92-98.

accuracies, comparison of; government careers; in-service training; physics classroom experiments; statistical consulting course; statistics; training; *20947*.

accuracy; activation analysis; count rate effects; dead time; errors; pulse pileup; *21249*.

accuracy; bioassay performance; occupational radiation protection standards; performance criteria; quality control; radiation instrument performance; radiation measurements; regulatory standards; *SP609*; 1982 February. 149-169.

accuracy; calibration; electro-optical measurements; frequency response; interferometric measurements; Kerr effect; Pockels effect; polarization; *SP628*; 1982 June. 1-19.

accuracy; high purity materials; instrumental neutron activation analysis; precision; reference materials; standards; trace analysis; *20997*.

accurate data; end user; host independent; monitor; network; performance; remote; response time; series/1; sidestreaming; simulated commands; 327X emulator; *SP500-95*; 1982 October. 401-407.

accurate measurements; benefit-cost analysis; cost savings; economic analysis; photomask linewidth measurements; semiconductors; *NBSIR 82-2458*.

ac current measurements; ac voltage measurements; ac-dc comparator; ac-dc difference; thermoelement; *TN1166*.

ac-dc comparator; ac-dc difference; thermoelement; ac current measurements; ac voltage measurements; *TN1166*.

ac-dc difference; data conversion; dynamic response; linearity; metrology support; phase angle calibration; signal sampling; stability; waveform synthesis; *21027*.

ac-dc difference; thermoelement; ac current measurements; ac voltage measurements; ac-dc comparator; *TN1166*.

acetylene; angular distribution; photoionization; synchrotron radiation; *21006*.

acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; *JPCRD 11(1)*: 83-99; 1982.

ace type pin tumbler lock; cheek plate tamper resistance; salt spray corrosion resistance; warded lock; *21199*.

acid; carbodiimide; degradation; hydrolysis; kinetics; polyester; polyurethane; *20972*.

acid etch; adhesive bonding; composites; dental resins; fillers; pedodontics; *20915*.

acid etch; BIS-GMA; bonding; composites; dental resins; fillers; *20847*.

acidity; acid rain; chemical analysis; conductance; pH; precipitation; rain; reference materials; trace elements; *NBSIR 82-2581*.

acid rain; chemical analysis; conductance; pH; precipitation; rain; reference materials; trace elements; acidity; *NBSIR 82-2581*.

ac Josephson effect; dc Josephson effect; Josephson junctions; superconductivity; supercurrent; tunneling; *21316*.

acoustical measurements; acoustic resonator; adsorption; nitrogen; physical acoustics; precondensation; propane; sorption; speed of sound; velocity of sound; *21230*.

acoustic emission; calibration; leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; radiography; standards; traceable measurements; visual testing; *21398*.

acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; and ultrasonics; *NBSIR 82-2449*.

acoustic emission; eddy currents; leak rate measurements; liquid penetrants; magnetic particles; neutron radiography; traceable NDE; visual acuity; *21166*.

acoustic emission; eddy currents; liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; radiography; tire inspection; ultrasonics; visual-optical; *20957*.

acoustic emission; elastic wave; nondestructive evaluation; Rayleigh wave; transducer; ultrasonic; *21098*.

acoustic emission; hermeticity; hybrid microelectronics; hybrid packages; microelectronic packaging; thermal shock; vibration; *SP400-70*.

acoustic emission simulator; acoustic emission transducers; nondestructive evaluation; penetrant test block; traceable measurements; ultrasonic reference blocks; ultrasonic transducers; x-ray magnifier; *21181*.

acoustic emission transducers; nondestructive evaluation; penetrant test block; traceable measurements; ultrasonic reference blocks; ultrasonic transducers; x-ray magnifier; acoustic emission simulator; *21181*.

acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; *NBS-GCR-80-204*.

acoustic material signatures; acoustic microscopy; scanning acoustic microscopy; semiconductor devices and integrated circuit inspection; *NBS-GCR-81-363*.

acoustic material signatures; acoustic microscopy; scanning acoustic microscopy; semiconductor devices and integrated circuit inspection; *NBS-GCR-82-401*.

acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; *NBS-GCR-80-204*.

acoustic microscopy; scanning acoustic microscopy; semiconductor devices and integrated circuit inspection; acoustic material signatures; *NBS-GCR-81-363*.

acoustic microscopy; scanning acoustic microscopy; semiconductor devices and integrated circuit inspection; acoustic material signatures; *NBS-GCR-82-401*.

acoustic resonator; adsorption; nitrogen; physical acoustics; precondensation; propane; sorption; speed of sound; velocity of sound; acoustical measurements; *21230*.

acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; *NBS-GCR-80-204*.

acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; *NBS-GCR-80-204*.

acoustic waves; cracks; finite element method; nondestructive evaluation; scattering; ultrasonic waves; variational method; *21229*.

acoustic waves; elastic anisotropy; nondestructive evaluation; stainless steel; ultrasonic scattering; ultrasonic waves; *21224*.

acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; *21223*.

acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; *21236*.

acousto-optic; bandshape; bandwidth; broadening; laser; modulation; noise; *21375*.

acquisition benchmarks; benchmark construction; forecasting; synthetic software; *SP500-95*; 1982 October. 443-448.

ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure;  $\text{Ba}^+$ ; blackbody radiation; Cs; frequency standards;  $\text{Hg}^+$ ; *21205*.

ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure;  $\text{Ba}^+$ ; blackbody radiation; Cs; frequency standards;  $\text{Hg}^+$ ; *21217*.

actinide; energy; energy levels; ionization parametric interpretation; thorium; wavelengths; *20878*.

actimetry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; transfer standard; absolute calibration; absolute quantum yield; *21045*.

activation analysis; count rate effects; dead time; errors; pulse pileup; accuracy; *21249*.

activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation; *TN1160*.



activation energies; bond-energy-bond-order; CN; ethynyl; radicals; abstraction reactions; 20781.

activation energy for double kink formation; boundary conditions for atomic simulations; brittle crack growth rate; double kink nucleation; edge dislocation pileup; equilibrium jog array; Mode I brittle crack; 21193.

active; antenna; filter; monopole; tracking; tuneable; 20892.

active site; charge relay; enzymes; protein structure; ribonuclease; x-ray diffraction; 20893.

active site; hydrogen bonds; protein structure; ribonuclease-S; semi-synthetic proteins; x-ray methods; 20914.

active solar; evaluation process; hot water; passive solar; performance criteria; solar energy; thermal performance; NBS-GCR-82-397.

active vibration control; Michelson interferometer; optical path-length correction; phase comparator; real-time control; vibration control; vibration isolation; 21403.

activity coefficient; correlation; critical evaluation; electrolyte theories; models; osmotic coefficient; polyvalent electrolytes; thermodynamics properties; 20935.

activity coefficient; critical evaluation; electrolyte; excess Gibbs energy; osmotic coefficient; solutions; thermodynamic properties; 20936.

activity coefficient; electrolyte; excess Gibbs energy; isopiestic; nickel nitrate; osmotic coefficient; solubility; solutions; thermodynamics; 21234.

activity coefficient; electrolytes; excess Gibbs energy; isopiestic; osmotic coefficient; potassium carbonate; solubility; solutions; thermodynamics; 21233.

activity coefficients; alkylbenzenes; gas chromatography; octanol/water partition coefficients; *J. Res.* 87(4): 311-315; 1982 July-August.

activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; NBSIR 81-2356.

activity coefficients; benzene; cyclohexane; evaluation procedures; excess Gibbs function; vapor-liquid equilibrium; JPCRD 11(4): 1099-1127; 1982.

activity coefficients; binary aqueous systems; enthalpies of dilution; enthalpy; entropy; flue gas desulfurization; Gibbs energy osmotic coefficients; thermochemical tables; NBSIR 81-2345.

activity coefficients; gas chromatography; octanol/water partition coefficients; solubility parameters; *J. Res.* 87(2): 155-158; 1982 March-April.

ac voltage measurements; ac-dc comparator; ac-dc difference; thermoelement; ac current measurements; TN1166.

ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; 21217.

ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; 21205.

adaptive control; air handling unit; direct digital control; energy management and control systems; HVAC system control; parameter estimator; PI-controller; recursive least squares algorithm; self-tuning control algorithm; NBSIR 82-2591.

adaptive meshes; eigenvalues; elliptic equations; finite elements; multi-level iterations; triangulations; 20823.

additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; petroleum; petroleum testing; recycled oil; re-refining; used oil recycling; 21397.

additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review; NBSIR 82-2490.

additives; computer models; flame spread; pyrolysis; solid fuels; NBS-GCR-82-396.

additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; NBSIR 81-2314.

adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; TN1150.

adhesion; measurement; protective coatings; test apparatus; test method; NBSIR 82-2535.

adhesive bonding; composites; dental resins; fillers; pedodontics; acid etch; 20915.

adiabatic; calorimeter; polyethylene film; thermistor; water calorimeter; absorbed dose; U.S. Patent 4,312,224.

adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; specific heat; thermosetting polymers; varnishes; 21032.

adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; 20930.

adiabatic electronic-rotational states; atomic scattering; distorted wave approximation; fine structure transitions; Hund's coupling; WKB approximation; 20786.

adiabatic nuclei approximation; molecular collisions; stopping cross sections; 21074.

adjacent reentry; density at interface; distribution of polymer loops; interfacial thickness; polymer; polymer interfaces; 21065.

adjacent reentry; fold plane roughening; melt crystallization; polyethylene; polyethylene fold planes; polymer; polymer crystallization; SANS; semicrystalline polymer; 21160.

adjacent reentry model of crystal and amorphous phase in polymer; polymer; semicrystalline polymer; small angle neutron scattering; switchboard model of polymer surface; 21161.

administrative experiment; air pollution; emissions trading; ETIP; innovation; offsets; NBSIR 82-2475.

administrative experiments; economic assistance; innovation; procurement; regulation; research and development; technology policy; NBS-GCR-ETIP 82-100.

administrative system for maintenance; automatic condition monitoring; condition monitoring module; microcomputer; SP640; 1982 October. 71-85.

ADP effectiveness; computer performance evaluation (CPE); computer performance management (CPM); service levels; user service reporting system (USRS); NBS-GCR-82-382.

ADP planning; Federal ADP procurement; life cycle management; long-range planning; systems planning and control; SP500-95; 1982 October. 11-18.

ADP security; backup operations; computer security; contingency planning; emergency response; Federal Information Processing Standards Publication; recovery actions; SP500-85.

adsorbed monolayers; Raman spectra of monolayers; surface enhanced Raman spectroscopy (SERS); surface plasmons; surface roughness; 21068.

adsorbed water; electrical conductivity; nonlocal process; surface conductivity; surface phenomena; SP400-72; 1982 April. 149-164.

adsorption; carbon monoxide on Ni(111); electron stimulated desorption; ESDIAD; low energy electron diffraction; thermal desorption; 21100.

adsorption; chemisorption; dissociation; halocarbon; halogen; iron; 21154.

adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; TN1150.

adsorption; corrosion; dew point; failure modes; hybrid manufacturing; moisture sources; SP400-72; 1982 April. 117-125.

adsorption; dew point; hygrometer; kinetics; microelectronic package; moisture; moisture level; relative humidity; sorption thermodynamics; absorption; SP400-72; 1982 April. 184-200.

adsorption; electrode processes; N-methylpyridinium iodide; pyridine derivatives; Raman spectroscopy; silver electrode; surface-enhanced Raman spectroscopy; 21262.

adsorption; many-body theory; photoemission; relaxation; 21151.

adsorption; nitrogen; physical acoustics; precondensation; propane; sorption; speed of sound; velocity of sound; acoustical measurements; acoustic resonator; 21230.

Advanced Computer System; selection criteria; software standards; SP500-94; 1982 October. 36-39.

aerosol coagulation; combustion aerosols; particle size distribution; smoke; smoke detection; smoke production; smoldering; 21231.

aerosolized fibers; airborne asbestos; analytical methods; contamination; filter loading; SP619; 1982 March. 77-84.

age-strength relation; building codes; compressive strength; concretes; regression analysis; safety; shear properties; splitting tensile strength; statistical analysis; 21150.

aggregates; concretes; creep tests; fire tests; high temperature tests; NBS-GCR-82-407.

aging; dielectric; distribution; electrical failure; polyethylene; reflectometry; rf characteristics; transmission; treeing; 21140.



agricultural water uses; demand reduction; drought emergency plans; educational programs; rural areas; water conservation; *SP624*; 1982 June. 465-469.

airborne asbestos; analytical methods; contamination; filter loading; aerosolized fibers; *SP619*; 1982 March. 77-84.

airborne asbestos; error distributions; Gaussian assumptions; membrane filter method; statistical considerations; *SP619*; 1982 March. 145-153.

airborne asbestos fibers; electron microscopic analysis; EPA-NBS agreement; methodology manual; standardized measurement protocol; *SP619*; 1982 March. 1-4.

air conditioner; energy analysis; equipment performance; gas furnace; heat pump; simplified calculation; *21141*.

air conditioning; air distribution; building systems; computer; control; modeling; office building; thermal response; ventilation; *21047*.

air conditioning; building systems; computer; control; heat exchanger; modeling; monitoring; research; steam; thermal response; valve; *21048*.

air-cooling; air leakage; energy; heat-recovery; insulation; measurement; office-building; radiant; solar; space-heating; *20961*.

aircraft compartments; aircraft fires; ceilings; compartment fires; computer programs; fire growth; fire models; heat flux; mathematical models; walls; *NBS-GCR-82-404*.

aircraft compartments; aircraft fires; flow rates; mathematical models; wind effects; *NBSIR 82-2537*.

aircraft fires; ceilings; compartment fires; computer programs; fire growth; fire models; heat flux; mathematical models; walls; aircraft compartments; *NBS-GCR-82-404*.

aircraft fires; flow rates; mathematical models; wind effects; aircraft compartments; *NBSIR 82-2537*.

aircraft hydraulic fluid; aircraft wheel bearing grease; instrument bearing lubrication; low temperature fluidity; synthetic hydrocarbon oils; *SP640*; 1982 October. 348-363.

aircraft maintenance functions; maintenance information systems functions; management and financial functions; master planning; material and logistics functions; personnel/component/support shop functions; powerplant/component/support shop functions; *SP640*; 1982 October. 27-44.

aircraft wheel bearing grease; instrument bearing lubrication; low temperature fluidity; synthetic hydrocarbon oils; aircraft hydraulic fluid; *SP640*; 1982 October. 348-363.

air density; index of refraction of air; refractivity of air; wavelength of light in air; *21276*.

air distribution; building systems; computer; control; modeling; office building; thermal response; ventilation; air conditioning; *21047*.

air flows; compartment fires; entrainment; fire plumes; flow rates; opening flows; *NBSIR 82-2520*.

air handling unit; direct digital control; energy management and control systems; HVAC system control; parameter estimator; PI-controller; recursive least squares algorithm; self-tuning control algorithm; adaptive control; *NBSIR 82-2591*.

air leakage; energy; heat-recovery; insulation; measurement; office-building; radiant; solar; space-heating; air-cooling; *20961*.

air mass; ASTM E 424; integrating sphere spectrophotometer; reflectance; selected ordinate; solar absorber materials; solar cover plates; transmittance; weighted ordinate; *NBSIR 81-2448*.

air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photo-absorption cross section; photochemistry; quantum yield; rate coefficient; *JPCRD 11(2)*: 327-496; 1982.

air pollution; atmospheric chemistry; chlorine monoxide; ClO; diode laser; infrared; spectra; *21303*.

air pollution; biogenic/fossil carbon impact; field and slash burning; Portland aerosol characterization study; radiocarbon; residential wood burning; urban particulates; vegetative burning; *20964*.

air pollution; dioxirane; dipole moment; microwave spectrum; ozone-olefin reactions; structure; *21340*.

air pollution; emissions trading; ETIP; innovation; offsets; administrative experiment; *NBSIR 82-2475*.

air pollution modeling; air quality; contaminant control; standards; tobacco smoke; ventilation; *20848*.

air quality; contaminant control; standards; tobacco smoke; ventilation; air pollution modeling; *20848*.

air scatter; calibration; californium; dose equivalent; dosimeter; neutron; remmeter; room return; *SP633*.

alanine; biographic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; radiochromic dye; *20889*.

alcohol; carbon monoxide; carboxyhemoglobin; cardiovascular disease; fire fatalities; hydrogen cyanide; *20812*.

alcohol; carbon monoxide; cigarettes; fatalities; fire; heart disease; heavy metals; hydrogen chloride; scenario; *20858*.

algebra by computer; Birkhoff normalisation; celestial mechanics; resonances; satellite theory; *20777*.

algebra of series; celestial mechanics; orbit calculations; *20806*.

algorithm; capacity assignment; computer communication network; tree topology; *SP500-95*; 1982 October. 173-182.

algorithm; converter; distortion; microcomputer; rms value; sampling; signal period; *TN1159*.

algorithms; calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; software; sorption; water; *SP400-72*; 1982 April. 3-7.

alkali dimers; excimer laser; free-bond absorption; gain cross section; *21322*.

alkanes; alkenes; C-H vibrations; laser photoacoustic spectroscopy; *21371*.

alkenes; C-H vibrations; laser photoacoustic spectroscopy; alkanes; *21371*.

alkylbenzenes; gas chromatography; octanol/water partition coefficients; activity coefficients; *J. Res. 87(4)*: 311-315; 1982 July-August.

alkyldioxy; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; *21254*.

alkyldioxy; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; *21255*.

alkyl halide; breakdown curve; metastable transition; photoelectron photoion coincidence; propylene; proton affinity; *21097*.

alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; *NSRDS-NBS70*.

alloy; aluminum alloy; elastic constants; flywheel; iron alloy; mass density; mechanical property; titanium alloy; *NSRDS-NBS61, Part V*.

alloy; amalgam; dental; dimensional change; expansion; *21156*.

alloying; alloy phase diagrams; charge transfer; hybridization; isomer shift; Mössbauer effect; *20820*.

alloy phase diagrams; charge transfer; hybridization; isomer shift; Mössbauer effect; alloying; *20820*.

alloys; anodic polarization; corrosion; fatigue; microstructures; titanium; *21174*.

alloys; coal conversion; coal gasification; corrosion; erosion; materials properties; mechanical properties; physical properties; refractories; *SP642*.

alloys; conductivity; electrical property; metals; polymers; resistance; resistivity; review; *TN1053*.

alloys; containers; corrosion; corrosion data; geothermal brines; metals; nuclear waste; underground; *NBSIR 81-2409*.

alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground; *NBSIR 82-2509*.

alpha-particle-emission rates; liquid-scintillation counting; plutonium-239 (half life); plutonium isotopic abundances; radioactive decay; *21246*.

alternate immersion; corrosivity monitoring device; exposure tests; marine environments; salt fog; *SP640*; 1982 October. 476-494.

alternate routing; circuit switching; communications networks; distributed control; integrated switching; packet switching survivability; *NBSIR 82-2588*.

alternate routing; communications networks; distributed control; message delay; network throughput; survivability; *20994*.

alternating voltage; charge-transfer; corrosion; electrochemistry; frequency analysis; rectification; *20886*.

aluminium; clusters; copper; gold; silver; single crystal; thin films; *21012*.

aluminium; anodizing; electrodeposition; nickel adhesion; plating; *21267*.

aluminum alloy; elastic constants; flywheel; iron alloy; mass density; mechanical property; titanium alloy; alloy; *NSRDS-NBS61, Part V*.

aluminum-doped silicon; dopant profiles; gallium doped silicon; resistivity profiles silicon; spreading resistance; thyristor; *21083*.

aluminum mirrors; directional specular reflectance; reflectance



specular; reflectance standards; second surface mirrors; solar reflectance; specular spectral reflectance; *SP260-79*.

aluminum mirrors; first-surface mirrors; specular reflectance; specular standards; standard mirrors; standard reference material; absolute reflectance; *SP260-75*.

aluminum non-skid coating; corrosion control; erosion; flame spray process; plasma coatings; thermal deposition systems; thermospray process; wear; *SP640*; 1982 October. 194-196.

aluminum oxide; Cerdip packages; IC assembly; in-situ moisture sensors; LSI circuits; mass spectrometry; on-going monitoring activity; package-sealing environment; *SP400-72*; 1982 April. 113-116.

aluminum oxide; corundum; drop calorimetry; enthalpy; heat capacity; high temperature; standard reference material; synthetic sapphire; *J. Res. 87(2)*: 159-163; 1982 March-April.

aluminum-oxide interlayer; Auger; capacitance-voltage; electron devices; ellipsometric; integrated circuits; *20827*.

aluminum oxide moisture sensor; moisture sensors; pn junction temperature sensor; surface conductivity sensor; time response of moisture sensors; *SP400-72*; 1982 April. 79-89.

aluminum oxide sensors; Cerdip; Cerpak; leak detection; mass spectrometry; Method 1018; moisture sensors; surface conductivity sensors; *SP400-72*; 1982 April. 90-97.

aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; *SP260-77*.

aluminum-silver alloys; cellular growth; electron beam; interface velocity; rapid solidification; stability; surface melting; *21263*.

Al(111); ammonia; desorption; electron stimulated desorption ion angular distribution; surface chemistry; surface structure; *21172*.

Al<sup>2+</sup>; crossed beams; cross sections; electron impact; excitation-autoionization; ionization; Mg<sup>+</sup>; Na iso-sequence; Si<sup>3+</sup>; *21073*.

amalgam; apparatus; composite; dental; instrumentation; pin and disc; restorative; wear; *20916*.

amalgam; dental; dimensional change; expansion; alloy; *21156*.

ambient air; asbestos; EPA provisional method; fibers; sampling errors; *SP619*; 1982 March. 154-161.

Amdahl's Law; benchmarking; computing environment; large-scale scientific computing; parallel processing; scientific workload; vector processing; *SP500-95*; 1982 October. 121-126.

American Association for Laboratory Accreditation; International Laboratory Accreditation Conference; laboratory accreditation system; task force C; *SP632*; 1982 March. 73.

American National Standards Institute; computer standards; DBMS; database management; database standards; Data Base System Study Group; query language; relation; relational model; Relational Task Group; *NBS-GCR-82-379*.

American Water Works Association; technical information programs; technical information retrieval; *SP624*; 1982 June. 37-45.

American Water Works Association (AWWA); conservation policy; water conservation; *SP624*; 1982 June. 207-209.

amide protection; flexibility; hydrogen exchange; protein structure; refinement; ribonuclease; *21137*.

amino acid analysis; anion-exchange; cytochrome c; enzymatic digestion; high-performance liquid chromatography; peptides; *21293*.

aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; alkyl radicals; *NSRDS-NBS70*.

ammonia; desorption; electron stimulated desorption ion angular distribution; surface chemistry; surface structure; Al(111); *21172*.

amorphous; cooling rate; crystalline; dendrites; interfaces; microcrystalline; nucleation; recalcence; solidification; undercooling; *21090*.

amorphous alloys; coupled growth; eutectic solidification; metallic glasses; palladium-copper-silicon alloys; rapid solidification; *21190*.

amorphous ferromagnet; exchange interaction; spin detector; spin-orbit interaction; spin polarization; *21087*.

amorphous materials; ferromagnetism; magnetization; neutron diffraction; spin waves; transition metals; *20945*.

amorphous phase; crystal-amorphous interface; fold surface; loops; polymer; semicrystalline polymer; tie molecules; *21159*.

amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; transfer standard; absolute calibration; absolute quantum yield; actinometry; *21045*.

AMRF; artificial intelligence; automated manufacturing; expert systems; knowledge-based systems; knowledge engineering; knowledge representation; problem solving; process planning; *NBSIR 81-2466*.

anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; *21326*.

analgesic; anticonvulsant; azepine ring; carbamazepine; crystal structure; molecular structure; USP reference standard; x-ray diffraction; *21298*.

analog signal conditioning; data acquisition system; field data acquisition; field instrumentation; field performance of heat pumps; heat pumps; heat pump test methods; microcomputer; *NBSIR 81-2285*.

analog-to-digital converter; digital processing; dynamic testing; sine-wave testing; transient digitizer; transient response; waveform recorder; *SP634*; 1982 June. 27-34.

analog-to-digital converter; digitizer; dynamic testing; effective number of bits; frequency domain; quantizing error; signal-to-noise ratio; time domain; transient recorder; *SP634*; 1982 June. 7-21.

analog to digital converter; superconducting interferometers; *U.S. Patent 4,315,255*.

analog-to-digital converters; code transition levels; converter testing; dynamic testing; high resolution; settling time; step response; *20908*.

analog-to-digital converters; error caused by response time; impulse measurements; numerical correction; *SP628*; 1982 June. 341-354.

analysis; asbestos; electron microscopy; occupational monitoring; optical microscopy; *SP619*; 1982 March. 132-137.

analysis; asbestos fibers; chrysotile filter; filter homogeneity; Poisson statistical process; statistical methods; *SP619*; 1982 March. 169-182.

analysis; bridges; crack propagation; failure; fatigue; fracture; fracture surface; fracture toughness; *SP621*; 1982 October. 95-109.

analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; moisture generators; moisture sensors; quality control; reliability of semiconductor devices; semiconductor devices; *SP400-72*.

analytical; capacity planning; central server; disk; main memory contention; modeling; packet switch; performance evaluation; simulation; trunk; WIN; *SP500-95*; 1982 October. 97-106.

analytical balance; balance dynamics; balance sensitivity; balance suspension; knife-edge bearings; Mathieu's equation; single-pan balance; *J. Res. 87(1)*: 23-45; 1982 January-February.

analytical blank; contamination control; sample handling; sample storage; sampling; trace element analysis; *21373*.

analytical laboratories; clients; international trading; laboratory accreditation; public; *SP632*; 1982 March. 46-51.

analytical laboratories; correlation; microcircuits; MIL-STD-8833; moisture measurement; moisture standards; *SP400-72*; 1982 April. 126-127.

analytical mathematical modeling; data base management; spatial economics; water conservation; water distribution systems; water supply simulation model; *SP624*; 1982 June. 239-245.

analytical methods; contamination; filter loading; aerosolized fibers; airborne asbestos; *SP619*; 1982 March. 77-84.

analytical procedures; hazardous waste management; lab procedures; Louisiana; Resource Conservation and Recovery Act; test protocols; training; *NBS-GCR-81-349*.

analytical procedures; hazardous waste management; lab procedures; Mississippi; Resource Conservation and Recovery Act; test protocols; training; *NBS-GCR-81-353*.

analytical procedures; hazardous waste management; lab procedures; model manual; monitoring; Resource Conservation and Recovery Act; State measurement needs; test protocols; *NBS-GCR-81-355*.

analytical procedures; hazardous waste management; lab procedures; Oklahoma; Resource Conservation and Recovery Act; test protocols; training; *NBS-GCR-81-350*.

analytical procedures; hazardous waste management; lab procedures; Pennsylvania; Resource Conservation and Recovery Act; test protocols; training; *NBS-GCR-81-351*.

analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; training; Virginia; *NBS-GCR-81-354*.

analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; Texas; training; *NBS-GCR-81-352*.

analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; training;



- analytical standards; asbestos standards; chemical composition; fibers; glass; physical dimensions; *SP619*; 1982 March. 21-28.
- analytic modeling; capacity planning; computer performance; modeling; models; software monitors; *SP500-95*; 1982 October. 81-84.
- anchors; cyclic loading; field testing; flood forces; foundations; load capacity; mobile homes; soil anchors; soil mechanics; stiffness; wind forces; *BSS142*.
- and ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; *NBSIR 82-2449*.
- anechoic chamber; calibrations; reflection errors; 20898.
- angiotensins; anion-exchange; high-performance liquid chromatography; hormones; peptides; 21294.
- angular distribution; photoionization; synchrotron radiation; acetylene; 21006.
- angular distributions; close-coupling approximation; CO<sub>2</sub> laser; elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; free-free transitions; Nd laser; photon-assisted transitions; 20787.
- angular distributions;  $c^4\Sigma_u^-$  limit; electrons; experimental; inelastic scattering; O<sub>2</sub>; Rydberg series; 21077.
- angular distributions; photoelectron spectroscopy; photoionization; 21292.
- angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; *NBS-GCR-80-204*.
- angular vibration; interferometer; reciprocity calibration; torsional vibration; absolute measurement; accelerometer calibration; 20967.
- anharmonic effects; Debye-Waller factor; lattice dynamics; lithium; molecular dynamics; rubidium; 21096.
- anharmonicity; combination band; high-resolution; molecular spectroscopy; transition moments; tunable lasers; 20924.
- anion-exchange; cytochrome c; enzymatic digestion; high-performance liquid chromatography; peptides; amino acid analysis; 21293.
- anion-exchange; high-performance liquid chromatography; hormones; peptides; angiotensins; 21294.
- anisotropic Yukawa potential; finite element; germanium; heavily doped semiconductors; impurity levels; silicon; 20830.
- annealing; boron; ion implantation; laser annealing; local mode; optical spectra; phonons; Raman spectra; silicon; spectra; thermal annealing; 21091.
- annual efficiency; household heaters and furnace test procedures; hydraulic thermostat control; modulating control gas-fueled; two-stage thermostat; *NBSIR 82-2497*.
- annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; transactions; *NBSIR 82-2575*.
- anodic oxidation; dissolution of passive films; ellipsometry; iron; passive films; potentiostat; 20882.
- anodic polarization; corrosion; fatigue; microstructures; titanium; alloys; 21174.
- anodizing; electrodeposition; nickel adhesion; plating; aluminum; 21267.
- anomalous dispersion; dimethyl sulfoxide; dosimetry; fibre optics; gamma-ray dosimetry; leuko cyanides; neutron dosimetry; optical waveguides; radiochromic dyes; 20804.
- ANOVA (within-between); components of variance; consensus values; design of experiments; pooling of variance; weighted average; weighted least squares regression; *J. Res.* 87(5): 377-385; 1982 September-October.
- ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; system parameters; transportable computer software; *TN1163*.
- ANSI Z39.2; bibliographic control; FIPS 30; format structure; machine-readable cataloging; machine-readable data files; MARC; MRDF; numeric data files; software summary; *SP500-94*; 1982 October. 189-196.
- Antares; calibration; inertial confinement fusion studies; pulse generators; *SP628*; 1982 June. 320.
- Antares Electron Gun; beam current; electron flux; *SP628*; 1982 June. 256.
- antenna; base station; fixed antennas; law enforcement; performance standard; radiation pattern; relative antenna gain; 20901.
- antenna; filter; monopole; tracking; tuneable; active; 20892.
- antenna directivity pattern; antenna measurements; calculated radiation parameters; polarization; standard antennas; VHF-UHF frequency range; wavelength-size scalar horns; 21222.
- antenna gain; antenna measurements; antenna pattern; antenna polarization; calibrations; near-field measurements; standard antennas; 21200.
- antenna measurements; antenna pattern; antenna polarization; calibrations; near-field measurements; standard antennas; antenna gain; 21200.
- antenna measurements; calculated radiation parameters; polarization; standard antennas; VHF-UHF frequency range; wavelength-size scalar horns; antenna directivity pattern; 21222.
- antenna measurements; compact range; planar near-field measurements; precision parabolic reflector; radar cross-section measurements; 21215.
- antenna pattern; antenna polarization; calibrations; near-field measurements; standard antennas; antenna gain; antenna measurements; 21200.
- antenna polarization; calibrations; near-field measurements; standard antennas; antenna gain; antenna measurements; antenna pattern; 21200.
- anticonvulsant; azepine ring; carbamazepine; crystal structure; molecular structure; USP reference standard; x-ray diffraction; analgesic; 21298.
- antiferromagnetic superconductors; chevrel-phase; ErRh<sub>4</sub>B<sub>4</sub>; ferromagnetic superconductors; neutron scattering; ternary superconductors; 21131.
- antiferromagnetism; critical fields; ferromagnetism; rare earths; scandium alloys; spin glass; 21129.
- antimony thioantimonate; electron microscopy; lubricant additive; solid lubricant; wear; wear debris; *NBSIR 82-2545*.
- antimony thioantimonate; extreme pressure and antiwear properties; greases; solid lubricant additive; abrasive wear; *SP640*; 1982 October. 150-161.
- antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review; additives; *NBSIR 82-2490*.
- antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; oligomers; polyethylene; polypropylene; radiotracer; *NBSIR 82-2472*.
- antistat-bearing steel interaction; antistatic agents; antistat-lubricant interaction; bearing packaging materials; bearing steel wettability; lubricant displacement; precision instrument bearings; *SP640*; 1982 October. 290-294.
- antistat agents; antistat-lubricant interaction; bearing packaging materials; bearing steel wettability; lubricant displacement; precision instrument bearings; antistat-bearing steel interaction; *SP640*; 1982 October. 290-294.
- antistat-lubricant interaction; bearing packaging materials; bearing steel wettability; lubricant displacement; precision instrument bearings; antistat-bearing steel interaction; antistat agents; *SP640*; 1982 October. 290-294.
- APD transfer standards; beamsplitter attenuator; impulse response measurements; low-level laser measurements; modulated cw measurement system; PIN transfer standards; pulse energy; pulse peak power; 1.064  $\mu$ m laser pulse measurements; *TN1058*.
- aperture; cavity; equivalence principle; field distribution; slot; *NBSIR 82-1659*.
- apparatus; composite; dental; instrumentation; pin and disc; restorative; wear; amalgam; 20916.
- apparent molal volume; aqueous sodium chloride solutions; compressibility; density; equation of state; expansivity; Pitzer's equations; *PVT*; volume; volumetric properties; *JPCRD 11(1)*: 15-81; 1982.
- appearance potential; charge transfer spectrum; electron impact ionization; ionization potential; photoelectron spectroscopy; photoionization; spectroscopy; *NSRDS-NBS71*.
- appliances; conservation programs; residential water conservation; water-saving plumbing devices; *SP624*; 1982 June. 193-196.
- appliances; fittings; fixtures; low flows; plumbing products; *SP624*; 1982 June. 289-292.
- application of basic queueing theory; IBM's RMF; job class; mathematical modeling; performance/modeling data acquisition; software monitor; *SP500-95*; 1982 October. 279-296.
- applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; research; state-of-the-art; *NBSIR 82-2505*.



applications; forecast; Japan; overview; research and development; robot; state-of-the-art; *NBSIR 82-2479*.

applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; renovation; 20909.

applied economics; building codes; health and safety; housing; mathematical programming; rehabilitation; renovation; *NBSIR 81-2416*.

approximate queueing model; computer architecture; performance modeling; queueing model; queueing networks; 20969.

approximation; clothoids; computer-aided design; Cornu-spirals; curvature; curve fitting; Fresnel-integrals; interpolation; splines; *J. Res. 87(4): 317-346; 1982 July-August*.

approximation techniques; queueing models; simulation; software package; systems performance; *SP500-95; 1982 October. 139-154*.

aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; *NBSIR 81-2356*.

aqueous sodium chloride solutions; compressibility; density; equation of state; expansivity; Pitzer's equations; *PVT*; volume; volumetric properties; apparent molal volume; *JPCRD 11(1): 15-81; 1982*.

aqueous solution; bibliography; bisulfite ion; chemical kinetics; oxidation; oxygen; sulfite ion; sulfur dioxide; *SP630*.

aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; *NSRDS-NBS70*.

aqueous standard fiber dispersions; asbestos analysis variability; fiber identification criteria; interlaboratory calibration; preparation techniques; *SP619; 1982 March. 91-107*.

arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; special relativity; surface charge conservation; transient propagation; 21327.

architecture; building design; cost-benefit analysis; economics; energy conservation; housing; insulation; space heating and cooling costs; space heating and cooling requirements; *NBSIR 81-2380*.

arctic pipelines; arc welding fluxes and wires; welding consumables; weld metal impact requirement; *SP621; 1982 October. 174*.

arc welding fluxes and wires; welding consumables; weld metal impact requirement; arctic pipelines; *SP621; 1982 October. 174*.

argon; binary mixtures; collision-induced absorption; potential functions; spectral moments; translational spectrum; wave mechanical lineshapes; 20929.

argon; computer programs; density; enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; *TN1048*.

argon; critically evaluated data; density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties; *JPCRD 11(Suppl. 1): 354 pp.; 1982*.

argon; laser spectroscopy; nonlinear spectroscopy; phase conjugation; 21162.

armor; ballistic helmets; ballistic impact; ballistic threat levels; bulletproof helmets; head protectors; 20913.

armor; ballistic protection; ballistic resistant materials; bulletproof glass; glazing materials; transparent armor; 20910.

armor; ballistic protection; ballistic threat; commercial body armor; performance standards; police body armor; protective undergarments; 20906.

Aroclor; dynamic intrinsic viscosity; internal viscosity; necklace model; polystyrene; 21059.

aromatic hydrocarbons; bond energies; ion-molecule reactions; proton affinities; radicals; 20950.

Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; *NSRDS-NBS72*.

arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; speciation; 21125.

arson; behavior disorder; fire; firesetters; motives; psychiatry; psychopathic personality; psychopathology; 21335.

arson; building design; combustion products; fire investigation; fire modeling; fire protection; human behavior; smoke control; smoldering; sprinkler systems; toxicity; *SP639*.

arson; decision analysis; fire investigations; firesetters; accelerants; 21256.

artificial intelligence; automated manufacturing; expert systems; knowledge-based systems; knowledge engineering; knowledge representation; problem solving; process planning; AMRF; *NBSIR 81-2466*.

artificial intelligence; automation; computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems; *NBSIR 82-2582*.

artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; research; state-of-the-art; applications; *NBSIR 82-2505*.

artificial satellite; Hamiltonian; parallax transformation; third-order solution; transformation; 21381.

artificial weathering; cover plate materials; durability; natural weathering; solar collectors; solar energy; solar energy transmittance; tensile properties; weathering of cover plates; *TN1170*.

asbestos; asbestos analysis; asbestos standards; characterization; sources; *SP619; 1982 March. 5-20*.

asbestos; asbestos minerals; chrysotile fiber; EPA provisional method; filter; *SP619; 1982 March. 190-206*.

asbestos; bulk material; laboratory evaluation; optical method; sprayed insulation; *SP619; 1982 March. 44-52*.

asbestos; bulk standards; construction materials; health risk; polarized light microscopy; *SP619; 1982 March. 34-43*.

asbestos; electron microscopy; occupational monitoring; optical microscopy; analysis; *SP619; 1982 March. 132-137*.

asbestos; EPA provisional method; fibers; sampling errors; ambient air; *SP619; 1982 March. 154-161*.

asbestos analysis; asbestos standards; characterization; sources; asbestos; *SP619; 1982 March. 5-20*.

asbestos analysis; electron microscope; error; fibrils; laboratories; *SP619; 1982 March. 162-168*.

asbestos analysis variability; fiber identification criteria; interlaboratory calibration; preparation techniques; aqueous standard fiber dispersions; *SP619; 1982 March. 91-107*.

asbestos fiber; asbestos reference suspension; fiber loading; filters; ultrasonic baths; *SP619; 1982 March. 68-76*.

asbestos fiber; biological samples; electron microscope; fiber concentrations; standard samples; *SP619; 1982 March. 53-67*.

asbestos fibers; chrysotile filter; filter homogeneity; Poisson statistical process; statistical methods; analysis; *SP619; 1982 March. 169-182*.

asbestos fibers; light scattering; magnetic alignment; magnetic filtration; rapid fiber analysis; *SP619; 1982 March. 108-120*.

asbestos identification; asbestos standard; electron microscopy; fiber counts; sample preparation; *SP619; 1982 March. 138-144*.

asbestos minerals; chrysotile fiber; EPA provisional method; filter; asbestos; *SP619; 1982 March. 190-206*.

asbestos minerals; electron microscopical method; environment; EPA Provisional Methodology; particle technologist; *SP619; 1982 March. 183-189*.

asbestos reference suspension; fiber loading; filters; ultrasonic baths; asbestos fiber; *SP619; 1982 March. 68-76*.

asbestos standard; electron microscopy; fiber counts; sample preparation; asbestos identification; *SP619; 1982 March. 138-144*.

asbestos standards; asbestos statistics; electron microscopy; fibrous minerals; *SP619*.

asbestos standards; characterization; sources; asbestos; asbestos analysis; *SP619; 1982 March. 5-20*.

asbestos standards; chemical composition; fibers; glass; physical dimensions; analytical standards; *SP619; 1982 March. 21-28*.

asbestos statistics; electron microscopy; fibrous minerals; asbestos standards; *SP619*.

ascorbic acid derivatives; bis(phenylhydrazones); nitrogen-15; nitrogen-15 chemical shifts; nitrogen-15-proton coupling constants; n.m.r. spectroscopy; 21084.

ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; thermal comfort; *NBSIR 82-2585*.

ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall; *NBSIR 81-2393*.



ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; NBS; solar; solar domestic hot water system; stratification; test method; *BSS140*.

ASHRAE Standard 96-1980; BSE; collector efficiency; unglazed collector; *NBSIR 82-2522*.

ASHRAE 95; collectors; solar domestic hot water; solar simulator; standard; test method; *20940*.

asphalt viscosity; bitumen cooling time; roofing bitumens; *20843*.

assertions; data abstractions; implementation; PL/I; specifications; validation; *20943*.

assignment; Brent's algorithm; double hashing; requirements; retrieval; Tharp's algorithm; *21248*.

associated particle; fission cross section; uranium-235; 14 MeV neutron energy; *20861*.

associated particles; neutron imaging; neutron sources; pin-hole camera; position-sensitive proportional counter; *21312*.

associative ionization; energy pooling; lasers; photoelectron spectrum; superelastic collisions; *21221*.

assurance; measurements; radioactivity; radiopharmaceutical; standards; traceability; *SP609*; 1982 February. 99-110.

ASTM; building materials; fire resistance; fire tests; international; ISO; standards; Technical Advisory Group; *21139*.

ASTM committee E-36; inspection agencies; laboratories; testing; *SP632*; 1982 March. 68-69.

ASTM C-236; calibrated and guarded hot boxes; interlaboratory round robin tests; thermal conductance of building sections; *NBSIR 81-2443*.

ASTM E-5; fire tests; histories; test methods; *20789*.

ASTM E-5; fire tests; standards; *20805*.

ASTM E162; fire tests; flame spread; plastics; smoke chamber; tables; *NBSIR 81-2400*.

ASTM E 424; integrating sphere spectrophotometer; reflectance; selected ordinate; solar absorber materials; solar cover plates; transmittance; weighted ordinate; air mass; *NBSIR 81-2448*.

asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; *NBSIR 81-2393*.

asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; thermal comfort; ASHRAE comfort standards; *NBSIR 82-2585*.

asymmetry parameter; autoionization; branching ratios; innershell resonances; photoelectron spectroscopy; rare gases; synchrotron radiation; *21291*.

asymmetry parameter; spectroscopy; *21112*.

atactic; crystal; crystallinity; density; enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene; *JPCRD 11(2)*: 313-325; 1982.

ATE; calibration; traceability; *21028*.

ATE systems; calibration; computer; hardware; measurement; third generation ATE; third generation core system; *SP640*; 1982 October. 222.

atmospheric attenuation; atmospheric ozone; optical radiation measurements; radiometry; solar radiation; spectroradiometry; UV spectral measurements; *TN910-5*.

atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photo-absorption cross section; photochemistry; quantum yield; rate coefficient; air pollution; *JPCRD 11(2)*: 327-496; 1982.

atmospheric chemistry; chlorine monoxide; ClO; diode laser; infrared; spectra; air pollution; *21303*.

atmospheric motions; chromosphere; Sun; supergranulation; *21377*.

atmospheric ozone; optical radiation measurements; radiometry; solar radiation; spectroradiometry; UV spectral measurements; atmospheric attenuation; *TN910-5*.

atmospheric pollution; carbonaceous gases and particles; carbon cycle; chemical selectivity; climate; low-level counting; radiocarbon; accelerator mass spectrometry; *21041*.

atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; speciation; arsenic; *21125*.

atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; *20999*.

atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin; *NBSIR 81-2424*.

atomic beam; hydrogen; metastable states; optical pumping; *21102*.

atomic beams; cesium; frequency standards; lasers; metrology; spectroscopy; *21252*.

atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; ion storage; laser cooling; *21191*.

atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; microwave frequency standard; optical frequency standard; stored ions; *21202*.

atomic clock; atomic frequency standard; atomic spectroscopy; ion storage; spectroscopy; stored ion spectroscopy; *21285*.

atomic clock; atomic resonance frequency error; fixed offset frequency; main atomic peak; microwave power level changes; servo; sidelobe atomic peak; *U.S. Patent 4,331,933*.

atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; *21205*.

atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; *21217*.

atomic collisions; close-coupled scattering theory; dressed-atoms; inelastic cross-sections; laser; laser-induced collisions; radiation theory; stimulated emission; *21347*.

atomic collisions; intense laser fields; laser induced chemistry; *21116*.

atomic emission spectroscopy; cost-effective; data processing; infrared spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; *SP640*; 1982 October. 61-71.

atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; *21185*.

atomic energy levels; atomic spectra; Fe; iron; iron energy levels; *JPCRD 11(1)*: 135-241; 1982.

atomic frequency standard; atomic spectroscopy; frequency standard; ion storage; laser cooling; atomic clock; *21191*.

atomic frequency standard; atomic spectroscopy; frequency standard; microwave frequency standard; optical frequency standard; stored ions; atomic clock; *21202*.

atomic frequency standard; atomic spectroscopy; ion storage; spectroscopy; stored ion spectroscopy; atomic clock; *21285*.

atomic frequency standard; laser diode; laser stabilization; light shift; optical pumping; *21210*.

atomic frequency standard; laser frequency standard; optical pumping; rubidium beam; rubidium cell; rubidium frequency standard; *21203*.

atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; *21205*.

atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; *21217*.

atomic magnetism; helical spin structure; holmium single crystal; low temperature; magnetic spin structure; nuclear magnetism; nuclear orientation;  $\gamma$  rays; <sup>166m</sup>Ho-Ho *21017*.

atomic masses; binding energies; mass formula; nuclear shell effects; quartetting; supermultiplets; *20939*.

atomic masses; collision-induced absorption; concentration; correlation function; density; rare gas mixtures; spectral behavior; absorption spectrum; *21007*.

atomic mercury; degenerate four-wave mixing; excited state spectrum; saturation spectrum; *20983*.

atomic negative ions; doubly charged ions; mass spectrometry; Penning ion source; *21370*.

atomic ordering; iron; magnetism; manganese; yttrium; *20866*.

atomic polarization; dipole polarizabilities; infrared intensities; molecular polarizabilities; vibrational polarizabilities; *JPCRD 11(1)*: 119-133; 1982.

atomic resonance frequency error; fixed offset frequency; main atomic peak; microwave power level changes; servo; sidelobe atomic peak; atomic clock; *U.S. Patent 4,331,933*.

atomic scattering; distorted wave approximation; fine structure transitions; Hund's coupling; WKB approximation; adiabatic electronic-rotational states; *20786*.

atomic scattering theory; electron ionization of positive ions; *20869*.

atomic sodium; high power laser; ionization; multiphoton;



nonresonant; 21003.

atomic spectra; atomic wavelengths; He-like ions; isoelectronic sequence; spectra series; vacuum ultraviolet; x rays; 20803.

atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; 21185.

atomic spectra; Fe; iron; iron energy levels; atomic energy levels; *JPCRD 11(1)*: 135-241; 1982.

atomic spectroscopy; frequency standard; ion storage; laser cooling; atomic clock; atomic frequency standard; 21191.

atomic spectroscopy; frequency standard; microwave frequency standard; optical frequency standard; stored ions; atomic clock; atomic frequency standard; 21202.

atomic spectroscopy; ion storage; spectroscopy; stored ion spectroscopy; atomic clock; atomic frequency standard; 21285.

atomic spectroscopy; ion trap; laser cooling; light pressure; Penning trap; quadrupole rf trap; 21011.

atomic wavelengths; He-like ions; isoelectronic sequence; spectra series; vacuum ultraviolet; x rays; atomic spectra; 20803.

atomic weight; atomic weight of silver; coulometer; electrochemical equivalent; Faraday constant; fundamental constants; silver; silver coulometer; *J. Res. 87(1)*: 21-22; 1982 January-February.

atomic weight; Faraday constant; isotopic abundance; mass spectrometry; silica gel; silver; silver iodide; absolute ratios; *J. Res. 87(1)*: 9-19; 1982 January-February.

atomic weight; isotopic abundances; strontium; absolute ratios; *J. Res. 87(1)*: 1-8; 1982 January-February.

atomic weight of silver; coulometer; electrochemical equivalent; Faraday constant; fundamental constants; silver; silver coulometer; atomic weight; *J. Res. 87(1)*: 21-22; 1982 January-February.

atom pairs; binary-collision approximation; bound state effects; finite collision time effects; 20833.

atoms; cross section; electron-ion pairs; electron shells; molecules; photoionization; 21056.

attenuation; backscatter; bandwidth; index profile; measurements; optical fiber; *SP637, Volume 1*.

attenuation; bandwidth; fiber optic joints; fiber optics; fiber optics-single mode; index profile; measurements; *SP641*.

Atterberg Limit tests; compaction; compaction tests; heat flow; laboratory tests; soil moisture; soil tests; tests; thermal conductivity; thermal resistivity; *BSS149*.

AuAl<sub>3</sub>; energy gap; superconductivity; tunneling; 21351.

Auger; capacitance-voltage; electron devices; ellipsometric; integrated circuits; aluminum-oxide interlayer; 20827.

Auger; core-holes; mixed-valence; photoionization; resonance; ytterbium; 21105.

Auger electrons; copper; gold; nickel; photoelectrons; surface analysis; 20986.

Auger-electron spectroscopy; ESCA (electron spectroscopy for surface analysis); ion-scattering spectroscopy; secondary-ion mass spectroscopy; surface analysis; x-ray photoelectron spectroscopy; 21382.

Auger-electron spectroscopy; round robin; surface analysis; 20927.

Auger spectroscopy; convection; gallium-tin alloys; levitation calorimetry; segregation; specific heat; surface tension; thermophysical properties; tungsten; *NBSIR 82-2560*.

Auger spectroscopy; depth profiling; sputtering; surface analysis; thin films; x-ray spectroscopy; 20985.

austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence; *SP260-76*.

austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence; *SP260-78*.

authoring; human interface; on-line documentation; *SP500-94*; 1982 October. 236-241.

autoionization; branching ratios; innershell resonances; photoelectron spectroscopy; rare gases; synchrotron radiation; asymmetry parameter; 21291.

autoionization; collisions; dielectronic recombination; multicharged ions; scattering; 20880.

autoionization; oscillator strength; photoionization; Stark effect; 21036.

autoionization; photoelectron spectroscopy; shape resonance; synchrotron radiation; 21357.

autoionizing resonances; photoelectron angular distributions; photon energy; Rydberg state; 20870.

automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; specific heat; thermosetting polymers; varnishes; adiabatic calorimetry; 21032.

automated data systems; computer programs; documentation; Federal Information Processing Standards (FIPS); operations phase; *SP500-94*; 1982 October. 68-75.

automated data systems; user manuals; *SP500-94*; 1982 October. 225-229.

automated documentation; documentation standards; internal documentation; software engineering; *SP500-94*; 1982 October. 119-125.

automated machining; hierarchical control; manufacturing research; research facility; 21378.

automated manufacturing; automatic control; computer-aided design; computer-aided manufacturing simulation; hierarchical control systems; *NBS-GCR-82-414*.

automated manufacturing; automatic control; computer-aided design; computer-aided manufacturing; hierarchical control systems; simulation; *NBS-GCR-82-413*.

automated manufacturing; drill failure prediction; drill wear; finished dimensions; improper drilling; time-domain analysis; tool failure; tool wear; vibration signatures; 20795.

automated manufacturing; expert systems; knowledge-based systems; knowledge engineering; knowledge representation; problem solving; process planning; AMRF; artificial intelligence; *NBSIR 81-2466*.

automated NDE; Braking Inspection System (BIS); braking system performance; trains; *SP621*; 1982 October. 91.

automated noise measurement system; coaxial noise sources; controller; IEEE 488 Bus; total power radiometer; *NBSIR 81-1656*.

automated oscilloscope; computer aided measurement; laboratory automation; pulse analysis; pulse waveform analysis; waveform analysis; waveform recording; *SP634*; 1982 June. 55-67.

Automated Pulse Measurement System; electromagnetic waveform measurements; *SP628*; 1982 June. 392-407.

automated software testing tools; Automated Verification System; COBOL analyzer; *SP500-95*; 1982 October. 51-60.

automated software tools; dynamic analysis; formal analysis; software testing; software verification; static analysis; test coverage; validation; V,V&T techniques; V,V&T tools; *SP500-93*.

automated software tools; software lifecycle; software testing; software verification; test coverage; test data generation; validation; *SP500-98*.

automated test equipment; diagnostics; technology in truck maintenance; truck maintenance aids; *SP621*; 1982 October. 201-211.

automated test equipment; fault isolation diagnostics; functional subsystem; line replaceable units; malfunction; microprocessor controlled test set; symptom; test strategy; *SP640*; 1982 October. 223-234.

automated tools; program design; program documentation; program document standardization; program testing; software engineering; *SP500-94*; 1982 October. 95-109.

Automated Verification System; COBOL analyzer; automated software testing tools; *SP500-95*; 1982 October. 51-60.

automatic condition monitoring; condition monitoring module; microcomputer; administrative system for maintenance; *SP640*; 1982 October. 71-85.

automatic control; computer-aided design; computer-aided manufacturing; hierarchical control systems; simulation; automated manufacturing; *NBS-GCR-82-413*.

automatic control; computer-aided design; computer-aided manufacturing simulation; hierarchical control systems; automated manufacturing; *NBS-GCR-82-414*.

automatic C-V profiler analyses; carrier depth distributions; differential capacitance-voltage profiling; ion implantation; ranges of application and limitations; Schottky barrier diodes; SIMS and C-V profile comparisons; *SP400-71*.

automatic data processing; computer reports; grant data; residential buildings; solar data base; solar energy system; solar hot water, space heating and cooling; *NBSIR 81-2376*.

automatic data processing; data base; residential buildings; solar data base; solar energy systems; solar heating and cooling; *NBSIR 81-2369*.

automatic data processing; data dictionary/directory; residential buildings; solar data energy system; solar heating and cooling; *NBSIR 81-2357*.



automatic data processing (ADP); channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; *FIPS PUB 61-1*.  
 automatic implementation techniques; communication protocols; computer network protocols; formal description techniques; protocol specification methods; *21034*.  
 automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; *21250*.  
 automatic resistance bridges; gas thermometry; high-temperature platinum resistance thermometers; temperature fixed points; thermistor thermometers; thermocouple thermometers; thermodynamic temperatures; thermometry; *21019*.  
 automatic sprinklers; building codes; building construction; health care facilities; life cycle cost; Life Safety Code; *NBSIR 82-2558*.  
 automatic sprinklers; compartment fires; fire safety; life safety; room fires; sidewall sprinkler systems; thermal response; *NBSIR 82-2521*.  
 automatic test equipment; calibration; calibration traceability; dynamic standards; transport standards; *21025*.  
 automatic test system; computer-automated; re-entry vehicles; reliability assessment; *SP640*; 1982 October. 216-221.  
 automatic time comparison; deep space network; differential time transfer; frequency transfer; Global Positioning System; international time comparison; primary frequency standards; SI second; *21204*.  
 automatic titration; Karl Fischer reagent titration; moisture; nuclear safeguards; plutonium dioxide; water determination; *NBSIR 82-2496*.  
 automation; computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems; artificial intelligence; *NBSIR 82-2582*.  
 automation; computer aided manufacturing; glossary; materials handling; robotics; robots; *NBSIR 81-2340*.  
 automation; computer control; gas transmission; permeation; permeation time-lag; SRM 1470; standard reference materials; *21026*.  
 automotive crankcase oils; bench test procedures; catalysts; correlation; dispersancy; engine sequence tests; hot tube; laboratory bench tests; oxidation; solubilization; *21279*.  
 autopsy; biological; carboxyhemoglobin; fatalities; hydrogen cyanide; polymer; toxicity; *20811*.  
 auto safety hotline; defects; motor vehicle equipment; motor vehicles; NHTSA; safety-related defects; safety standards; *SP621*; 1982 October. 212-214.  
 avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; *NBSIR 81-2413*.  
 average price; economic analysis; marginal price; water conservation; water pricing; water rate schedules; *21142*.  
 avionic component design; avionic corrosion damage; corrosion damage; equipment design failures; marine environmental factors; moisture intrusion in avionic equipment; *SP640*; 1982 October. 379-399.  
 avionic corrosion damage; corrosion damage; equipment design failures; marine environmental factors; moisture intrusion in avionic equipment; avionic component design; *SP640*; 1982 October. 379-399.  
 azepine ring; carbamazepine; crystal structure; molecular structure; USP reference standard; x-ray diffraction; analgesic; anticonvulsant; *21298*.  
 azometalloycyle; benzotriazoleanion; copper complex; corrosion inhibitor; crystal structure; single crystal x-ray diffraction; tridentate ligand; *21297*.  
 azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; *JPCRD 11(1)*: 83-99; 1982.  
 A-123; data processing; computer crime; computer security; *SP500-95*; 1982 October. 89-94.

## B

Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure;

*21205*.

Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; *21217*.  
 background; calibration; californium neutrons; personnel monitoring; reflected neutrons; scattered neutrons; *20966*.  
 back pressurization; electronic packages; hermetic test; leak testing; *SP400-73*.  
 back pressurization; electronic packages; hermetic test; leak testing; *20856*.  
 backscatter; bandwidth; index profile; measurements; optical fiber; attenuation; *SP637, Volume 1*.  
 backscattering; backscatter signatures; optical fiber scattering; optical time-domain reflectometer; OTDR; *TN1050*.  
 backscattering; experiment; forward scattering; quenching; resonance; sodium; transport; *20953*.  
 backscatter signatures; optical fiber scattering; optical time-domain reflectometer; OTDR; backscattering; *TN1050*.  
 backup operations; computer security; contingency planning; emergency response; Federal Information Processing Standards Publication; recovery actions; ADP security; *SP500-85*.  
 backup operations; contingency planning; disaster recovery; empty shell; reciprocal aid; recovery center; redundant facilities; shared contingency facility; *SP500-95*; 1982 October. 439-441.  
 bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; *20999*.  
 bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; *20999*.  
 balance dynamics; balance sensitivity; balance suspension; knife-edge bearings; Mathieu's equation; single-pan balance; analytical balance; *J. Res. 87(1)*: 23-45; 1982 January-February.  
 balance sensitivity; balance suspension; knife-edge bearings; Mathieu's equation; single-pan balance; analytical balance; balance dynamics; *J. Res. 87(1)*: 23-45; 1982 January-February.  
 balance suspension; knife-edge bearings; Mathieu's equation; single-pan balance; analytical balance; balance dynamics; balance sensitivity; *J. Res. 87(1)*: 23-45; 1982 January-February.  
 balancing; diagnostics; faults; jet engines; monitoring; overhaul; productivity; vibration; *SP640*; 1982 October. 115-129.  
 ballistic helmets; ballistic impact; ballistic threat levels; bulletproof helmets; head protectors; armor; *20913*.  
 ballistic impact; ballistic threat levels; bulletproof helmets; head protectors; armor; ballistic helmets; *20913*.  
 ballistic protection; ballistic resistant materials; bulletproof glass; glazing materials; transparent armor; armor; *20910*.  
 ballistic protection; ballistic threat; commercial body armor; performance standards; police body armor; protective undergarments; armor; *20906*.  
 ballistic resistant materials; bulletproof glass; glazing materials; transparent armor; armor; ballistic protection; *20910*.  
 ballistic threat; commercial body armor; performance standards; police body armor; protective undergarments; armor; ballistic protection; *20906*.  
 ballistic threat levels; bulletproof helmets; head protectors; armor; ballistic helmets; ballistic impact; *20913*.  
 Balmer lines; ion dynamics; Lyman series; plasma broadening; plasma theory; relaxation theory; Stark broadening; *21368*.  
 band centers; carbonyl sulfide; diode laser spectra; heterodyne frequency measurements; infrared spectroscopy; rotational constants; *20852*.  
 bandgap narrowing; band states; donor impurities; Germi energy; silicon; Yukawa potential; *20921*.  
 bandgap narrowing; Bargmann potential; conduction states; donors; effective mass; energy dispersion; impurities; silicon; valence states; Yukawa potential; *20855*.  
 bandshape; bandwidth; broadening; laser; modulation; noise; acousto-optic; *21375*.  
 band states; donor impurities; Germi energy; silicon; Yukawa potential; bandgap narrowing; *20921*.  
 bandwidth; broadening; laser; modulation; noise; acousto-optic;



bandshape; 21375.

bandwidth; fiber optic joints; fiber optics; fiber optics-single mode; index profile; measurements; attenuation; *SP641*.

bandwidth; index profile; measurements; optical fiber; attenuation; backscatter; *SP637, Volume 1*.

Bargmann potential; conduction states; donors; effective mass; energy dispersion; impurities; silicon; valence states; Yukawa potential; bandgap narrowing; 20855.

barium; dysprosium; energy levels; erbium; gadolinium; neodymium; samarium; spectrum; tantalum; tungsten; ytterbium; 20845.

Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; residual stress; stress measurements; ultrasonics; x-ray diffraction; 20926.

barrier-free design; building accessibility; database analysis; accessibility; *NBSIR 82-2567*.

basalt; chemical characterization; data compilation; dielectric properties; electrical properties; mechanical properties; thermal properties; thermodynamic properties; thermophysical properties; *NBSIR 82-2587*.

base station; fixed antennas; law enforcement; performance standard; radiation pattern; relative antenna gain; antenna; 20901.

basestock; engine lubricants; lubricating oil; motor oil; petroleum oil; recycled oil; re-refined oil; test procedures; 20990.

basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review; additives; antioxidants; *NBSIR 82-2490*.

basic agreement solicitations; evaluation of system life costs; teleprocessing services procurements; unbalanced pricing; workload forecasting; *SP500-95*; 1982 October. 27-33.

basic weights and measures law; method of sale of commodities; open dating; packaging and labeling; registration of servicepersons; unit pricing; Weighmaster Law; *H130, 1983 Edition*.

batch; DSNAMES ENQUEUE conflict management; MVS SRM; resource-sensitive job scheduling; service levels; SMF exits; workload scheduling; *SP500-95*; 1982 October. 297-311.

battery-acid corrosion; metal coating; polymer coating; rust prevention; vehicular rust; *SP640*; 1982 October. 275-289.

Ba X; Cs IX; I VII; La XI; wavelengths; Xe VIII; 20815.

beam current; electron flux; Antares Electron Gun; *SP628*; 1982 June. 256.

beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy; 21175.

beamsplitter attenuator; impulse response measurements; low-level laser measurements; modulated cw measurement system; PIN transfer standards; pulse energy; pulse peak power; 1.064  $\mu\text{m}$  laser pulse measurements; APD transfer standards; *TN1058*.

bearing failure; bearing reliability; condition monitoring; roller bearings; thermal analysis; *SP640*; 1982 October. 295-325.

bearing life; bearings; epicyclic system; gear train; planet bearings; planetary gears; *SP640*; 1982 October. 130-149.

bearing packaging materials; bearing steel wettability; lubricant displacement; precision instrument bearings; antistat-bearing steel interaction; antistatic agents; antistat-lubricant interaction; *SP640*; 1982 October. 290-294.

bearing reliability; condition monitoring; roller bearings; thermal analysis; bearing failure; *SP640*; 1982 October. 295-325.

bearings; epicyclic system; gear train; planet bearings; planetary gears; bearing life; *SP640*; 1982 October. 130-149.

bearing steel wettability; lubricant displacement; precision instrument bearings; antistat-bearing steel interaction; antistatic agents; antistat-lubricant interaction; bearing packaging materials; *SP640*; 1982 October. 290-294.

beginning computer users; documentation; hardware systems documentation; large computer manufacturers; microcomputers; periodical literature and documentation; software documentation; user's groups; verbal documentation; *SP500-94*; 1982 October. 174-179.

behavioral studies; clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; thermal comfort; ASHRAE comfort standards; asymmetric heating/comfort; *NBSIR 82-2585*.

behavior disorder; fire; firesetters; motives; psychiatry; psychopathic personality; psychopathology; arson; 21335.

benchmark construction; forecasting; synthetic software; acquisition benchmarks; *SP500-95*; 1982 October. 443-448.

benchmarking; capacity planning; chargeback systems; computer performance management systems; queueing models; resource measurement facilities; simulation; supercomputers; workload characterization; *SP500-95*.

benchmarking; computing environment; large-scale scientific computing; parallel processing; scientific workload; vector processing; Amdahl's Law; *SP500-95*; 1982 October. 121-126.

bench test procedures; catalysts; correlation; dispersancy; engine sequence tests; hot tube; laboratory bench tests; oxidation; solubilization; automotive crankcase oils; 21279.

benefit-cost analysis; cost savings; economic analysis; photomask linewidth measurements; semiconductors; accurate measurements; *NBSIR 82-2458*.

benefit-cost analysis; energy conservation; equipment selection; equipment sizing; heat pump; life-cycle costs; *NBSIR 80-2176*.

benefits; costs; water conservation; water-related expenditures; *SP624*; 1982 June. 259-266.

benzene; cyclohexane; evaluation procedures; excess enthalpy; heat of mixing; *JPCRD 11(4)*: 1129-1151; 1982.

benzene; cyclohexane; evaluation procedures; excess Gibbs function; vapor-liquid equilibrium; activity coefficients; *JPCRD 11(4)*: 1099-1127; 1982.

benzene; cyclohexane; evaluation procedures; excess volume; volume change of mixing; *JPCRD 11(4)*: 1153-1171; 1982.

benzene; F-atom reactions; infrared spectrum; matrix isolation; phenyl; photodecomposition; 1-fluorocyclohexadienyl; 20917.

benzotriazoleanion; copper complex; corrosion inhibitor; crystal structure; single crystal x-ray diffraction; tridentate ligand; azometalloycycle; 21297.

beryl; KAP; metallic multilayers; reflectivity; resolving power; synchrotron radiation; 1 keV photon energy region; 21088.

beryllium; fixed points; liquid  $^3\text{He}$ ; superconductivity; temperature; transition temperature; tungsten; 21063.

beryllium; fixed points; superconductivity; superfluidity; tungsten; 21219.

Bethe-Heitler cross section; bremsstrahlung monochromator; photonuclear research; polarized bremsstrahlung differential cross section; polarized photon beams; tagged photon method; *NBSIR 82-2454*.

bibliographic citations; capitalization practices; database; orthography; *SP500-94*; 1982 October. 215-218.

bibliographic control; bibliographic standards; computer software; documentation standards; machine-readable data files (MRDF); *SP500-94*; 1982 October. 183-188.

bibliographic control; FIPS 30; format structure; machine-readable cataloging; machine-readable data files; MARC; MRDF; numeric data files; software summary; ANSI Z39.2; *SP500-94*; 1982 October. 189-196.

bibliographic data; data element dictionary; guidelines; *SP500-94*; 1982 October. 209-214.

bibliographic standards; computer software; documentation standards; machine-readable data files (MRDF); bibliographic control; *SP500-94*; 1982 October. 183-188.

bibliographies; building fires; coal mines; combustion products; compartment fires; fabric flammability; fire research; fire tests; flame research; smoke; *NBSIR 82-2499*.

bibliographies; evacuation; fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; sprinkler systems; *NBSIR 81-2438*.

bibliography; bisulfite ion; chemical kinetics; oxidation; oxygen; sulfite ion; sulfur dioxide; aqueous solution; *SP630*.

bibliography; physical acoustics; summary; ultrasonics; *NBSIR 82-2529*.

bid-modifier; disposal costs; PAR factor; procurement; purchasing; recovered/recycled materials; resource recovery; *NBS-GCR-82-400*.

billing systems; chargeback systems; charging systems; cost accounting; costing; DP accounting; pricing; *SP500-95*; 1982 October. 425.

binary aqueous systems; enthalpies of dilution; enthalpy; entropy; flue gas desulfurization; Gibbs energy osmotic coefficients; thermochemical tables; activity coefficients; *NBSIR 81-2345*.

binary-collision approximation; bound state effects; finite collision time effects; atom pairs; 20833.

binary mixtures; collision-induced absorption; potential functions; spectral moments; translational spectrum; wave mechanical lineshapes; argon; 20929.

binary stellar evolution; cataclysmic variables; compact binary x-ray



sources; gravitational radiation decay of binary orbits; 21010.

bin-averaged cross sections; dose-averaged energy loss; energy deposition spectra; energy distributed neutron spectra; frequency averaged energy loss; microdosimetric parameters; 21029.

binding energies; mass formula; nuclear shell effects; quartetting; supermultiplets; atomic masses; 20939.

bioassay performance; occupational radiation protection standards; performance criteria; quality control; radiation instrument performance; radiation measurements; regulatory standards; accuracy; SP609; 1982 February. 149-169.

biocide; chromatography; copolymers; kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; NBSIR 81-2424.

biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; 21272.

bioclimatic chart; human comfort; indoor environment; outdoor environment; thermal comfort; 21004.

bioeffects; dosimetry; electromagnetic; exposure; nonionizing; radiation; radiofrequency; regulation; safety; standards; 21038.

biogenic/fossil carbon impact; field and slash burning; Portland aerosol characterization study; radiocarbon; residential wood burning; urban particulates; vegetative burning; air pollution; 20964.

biological; carboxyhemoglobin; fatalities; hydrogen cyanide; polymer; toxicity; autopsy; 20811.

biological samples; electron microscope; fiber concentrations; standard samples; asbestos fiber; SP619; 1982 March. 53-67.

biolographic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; radiochromic dye; alanine; 20889.

biomass; heating and cooling; performance criteria; photovoltaics; solar energy systems; standards; wind energy; 21106.

biomass conversion R&D; bioprocess engineering; biotechnology; chemical industry trends/strategies; commodity organic chemicals; measurement/evaluated data needs; NBS research capabilities; NBSIR 82-2549.

biominerals; calcium carbonates; calcium oxalates; calcium phosphates; calcium pyrophosphate; crystal structures; hydroxyapatite; octacalcium phosphate; sodium urate; 21110.

bioprocess engineering; biotechnology; chemical industry trends/strategies; commodity organic chemicals; measurement/evaluated data needs; NBS research capabilities; biomass conversion R&D; NBSIR 82-2549.

biotechnology; chemical industry trends/strategies; commodity organic chemicals; measurement/evaluated data needs; NBS research capabilities; biomass conversion R&D; bioprocess engineering; NBSIR 82-2549.

Birkhoff normalisation; celestial mechanics; resonances; satellite theory; algebra by computer; 20777.

BIS-GMA; bonding; composites; dental resins; fillers; acid etch; 20847.

bis(phenylhydrazones); nitrogen-15; nitrogen-15 chemical shifts; nitrogen-15-proton coupling constants; n.m.r. spectroscopy; ascorbic acid derivatives; 21084.

bisulfite ion; chemical kinetics; oxidation; oxygen; sulfite ion; sulfur dioxide; aqueous solution; bibliography; SP630.

bitumen cooling time; roofing bitumens; asphalt viscosity; 20843.

blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; 21205.

blackbody radiation; Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; 21217.

BLACKJACK 5 pulse generator; calibration procedures; calibration pulsers; SP628; 1982 June. 150-164.

black paint; deuterium lamp; silicon photodiode; specular reflectance; ultraviolet reflectance; absorption coefficient; 20989.

bleaching of dyes; dose rate; dosimetry; dyes; film dosimetry; gamma rays; humidity effects; leucocyanines; pulse radiolysis; radiation processing; radiochromic dyes; 20844.

block copolymers; chain folding in polymers; copolymer; phase transition in polymers; polymer crystals; 21066.

blue-green laser; effective core potentials; excimer; rare-gas halide; transition moments; 21309.

board and care homes; developmentally disabled; elderly persons; evacuation; fire emergency planning; fire protection; group homes; mental disorders; NBS-GCR-82-408.

Bohm-Aharonov; electrical transformer; interference; quantum mechanics; uncertainty relations; vector potential; 20794.

boiler performance; central utility plant; diesel engine performance; engine-generator efficiency; environmental impact; heat recovery; total energy system; absorption chillers; NBSIR 82-2474.

boiler performance; diesel engine performance; engine-generator efficiency; integrated utility system; total energy systems-economic and engineering analysis; waste heat recovery; absorption chillers; NBSIR 82-2483.

Boltzmann equation; collision integral; kinetic theory; perturbation theory; transport coefficient; transport properties; 21197.

bombing; fine leak test; gross leak test; helium; hermeticity; tracer gas; SP400-72; 1982 April. 281-288.

bond distance; boron chloride; diode lasers; Dunham coefficients; infrared; spectra; unstable molecules; 20817.

bond distances; carbon diselenide; infrared; molecular structure; spectroscopy; vibrational spectra; 20801.

bond energies; ion-molecule reactions; proton affinities; radicals; aromatic hydrocarbons; 20950.

bond-energy-bond-order; CN; ethynyl; radicals; abstraction reactions; activation energies; 20781.

bonding; composites; dental resins; fillers; acid etch; BIS-GMA; 20847.

bone cement; hip prosthesis; stress analysis; surface preparation; surgical implant metals; test method; titanium; NBSIR 82-2563.

book prices; copyright law; inflation; interlibrary lending; journal prices; library photocopying; publishers; 21380.

borane monoammoniate; electric dipole moment; microwave spectrum; molecular structure; rotational spectrum; structure; 21337.

boric oxide; glass; sodium boron; sodium borosilicate; thermodynamics; transpiration; vaporization; 21108.

boring; drilling; energy; field tests; foundation design; hammer; in-situ tests; Standard Penetration Test; 20951.

boron; dopant profile control; ion channeling; ion implantation; silicon; silicon dioxide; 20824.

boron; ion implantation; laser annealing; local mode; optical spectra; phonons; Raman spectra; silicon; spectra; thermal annealing; annealing; 21091.

boron-aluminum; elastic constants; glass-epoxy; graphite-epoxy; internal friction; shear modulus; sound velocity; ultrasonic wave; Young's modulus; 20868.

boron chloride; diode lasers; Dunham coefficients; infrared; spectra; unstable molecules; bond distance; 20817.

Boson field theory; high-temperature series expansions; hyperscaling relations; Ising ferromagnet; Padé and integral approximants; renormalization group; 21080.

bottom injection; multiple injection; smoke candle test; smoke control; stairwell pressurization; top injection; tracer gas test; 21307.

boundary conditions for atomic simulations; brittle crack growth rate; double kink nucleation; edge dislocation pileup; equilibrium jog array; Mode I brittle crack; activation energy for double kink formation; 21193.

bound exciton; density of states; indium doped silicon; isoelectronic; optical properties; photoluminescence; silicon; 21146.

bound state effects; finite collision time effects; atom pairs; binary-collision approximation; 20833.

brachytherapy; calibration; cesium-137; dosimetry standards; iodine-125; iridium-192; radium; standards; 21311.

Braking Inspection System (BIS); braking system performance; trains; automated NDE; SP621; 1982 October. 91.

braking system performance; trains; automated NDE; Braking Inspection System (BIS); SP621; 1982 October. 91.

branching ratios; innershell resonances; photoelectron spectroscopy; rare gases; synchrotron radiation; asymmetry parameter; autoionization; 21291.

breakdown; dielectrics; high voltage; insulation; liquids; shock waves; 21352.

breakdown; electrical insulation; high voltage; liquids; partial discharge; polydimethylsiloxanes; 21130.

breakdown curve; metastable transition; photoelectron photoion coincidence; propylene; proton affinity; alkyl halide; 21097.

breakdown maintenance; labor problems; maintenance; management support; manpower utilization; worker productivity; SP640; 1982 October. 495-504.

breakdown of passivity; corrosion; electrochemistry; passivity;



repassivation; surface modification; 20928.

bremsstrahlung; cross sections; data base; electron; photon; transport; 21384.

bremsstrahlung; cross sections; elastic scattering; electron-impact ionization; electrons; photons; stopping power; transport; *NBSIR 82-2572*.

bremsstrahlung monochromator; photonuclear research; polarized bremsstrahlung differential cross section; polarized photon beams; tagged photon method; Bethe-Heitler cross section; *NBSIR 82-2454*.

bremsstrahlung radiation; Casino Facility; effects simulator; nuclear weapons; *SP628*; 1982 June. 118-132.

Brent's algorithm; double hashing; requirements; retrieval; Tharp's algorithm; assignment; 21248.

bridge; collapse; concrete; construction; failure investigation; falsework; field load tests; formwork; post-tensioning; structural analysis; *NBSIR 82-2593*.

bridges; crack propagation; failure; fatigue; fracture; fracture surface; fracture toughness; analysis; *SP621*; 1982 October. 95-109.

bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems; *SP621*.

brittle crack growth rate; double kink nucleation; edge dislocation pileup; equilibrium jog array; Mode I brittle crack; activation energy for double kink formation; boundary conditions for atomic simulations; 21193.

brittle fracture; failure; fatigue; rapid transit; steel frames; welding; *SP621*; 1982 October. 110-129.

brittle materials; ductile materials; fatigue; fractures; machines; stress systems; tension loading; *SP621*; 1982 October. 196-200.

broadcast; coaxial; communication; contention; data; digital; Ethernet; local; microprocessor; network; serial; 20839.

broadening; laser; modulation; noise; acousto-optic; bandshape; bandwidth; 21375.

$\text{Br}(\text{P}_{1/2})$ ;  $\text{I}(\text{P}_{1/2})$ ; laser; photofragmentation; photolysis; ultraviolet; 20785.

BSE; collector efficiency; unglazed collector; ASHRAE Standard 96-1980; *NBSIR 82-2522*.

building; collapse; concrete; concrete strength; construction; failure; flat plate; shear; strength; *BSS145*.

building; collapse; connection; construction; failure; steel; walkway; *BSS143*.

building; cooling; heating; hot water; performance criteria; solar energy; standards; *BSS147*.

building accessibility; building rehabilitation guidelines; code enforcement; earthquake requirements; energy conservation; existing buildings; rehabilitation; 21385.

building accessibility; database analysis; accessibility; barrier-free design; *NBSIR 82-2567*.

building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; *NBSIR 82-2562*.

building codes; building construction; health care facilities; life cycle cost; Life Safety Code; automatic sprinklers; *NBSIR 82-2558*.

building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; *NBS-GCR-82-383*.

building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; renovation; applied economics; 20909.

building codes; building fires; computer-aided design; computer simulation; emergency egress; fire research; human performance; modeling; pedestrian movement; regulatory process; simulation of human behavior; 20911.

building codes; compressive strength; concretes; regression analysis; safety; shear properties; splitting tensile strength; statistical analysis; age-strength relation; 21150.

building codes; health and safety; housing; mathematical programming; rehabilitation; renovation; applied economics; *NBSIR 81-2416*.

building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; *NBSIR 82-2562*.

building construction; health care facilities; life cycle cost; Life Safety Code; automatic sprinklers; building codes; *NBSIR 82-2558*.

building controls; digital-to-pneumatic conversion; direct digital control; energy controls; HVAC system; microprocessor control; pneumatic control system; velocity algorithm; 20995.

building control strategies; building energy conservation; building thermal performance; HVAC systems; *NBSIR 82-2580*.

building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; *NBS-GCR-82-383*.

building design; combustion products; fire investigation; fire modeling; fire protection; human behavior; smoke control; smoldering; sprinkler systems; toxicity; arson; *SP639*.

building design; cost-benefit analysis; economics; energy conservation; housing; insulation; space heating and cooling costs; space heating and cooling requirements; architecture; *NBSIR 81-2380*.

building drainage; computer model; surge attenuation; unsteady flow; *NBSIR 82-2478*.

building economics; commercial buildings; economic analysis; energy economics; life-cycle costing; solar energy; *NBSIR 82-2540*.

building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; 20909.

building energy analysis; computer simulation; infiltration; natural ventilation; 21123.

building energy conservation; building thermal performance; HVAC systems; building control strategies; *NBSIR 82-2580*.

building energy monitoring; heating, ventilating and air-conditioning controls; humidity; humidity control; humidity measurement; humidity sensor; hygrometer; *NBSIR 81-2460*.

building energy performance; building subsystem energy criteria; energy conservation in lighting; general lighting; illumination energy; lighting energy; task lighting; 21042.

building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; building design; *NBS-GCR-82-383*.

building fires; building materials; committees; fire tests; flashover; room fires; standards; 21118.

building fires; carbon monoxide; compartment fires; smoldering; *NBSIR 82-2556*.

building fires; coal mines; combustion products; compartment fires; fabric flammability; fire research; fire tests; flame research; smoke; bibliographies; *NBSIR 82-2499*.

building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; 21121.

building fires; computer-aided design; computer simulation; emergency egress; fire research; human performance; modeling; pedestrian movement; regulatory process; simulation of human behavior; building codes; 20911.

building fires; egress; elevators; handicapped; pressurization; smoke control; stairwells; 21226.

building fires; egress; elevators (lifts); evacuation; handicapped; pressurization; smoke control; stairwells; *NBSIR 82-2507*.

building fires; fire resistance; fire tests; flow measurement; gas temperatures; heat release rate; interior finishes; residential buildings; room fires; *NBSIR 80-2120*.

building heat transfer; DoE-2 energy analysis computer program; monthly average earth temperature; thermal response factors; *NBSIR 81-2420*.

building insulation; energy conservation; guarded hot plate; heat flow meter; heat transfer; low-density mineral fiber; thermal conductivity; thermal resistance; thickness effect; *NBSIR 82-2538*.

building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; building design; building fires; *NBS-GCR-82-383*.

building materials; building technology; construction; Department of Defense; Tri-Services Committee; 21039.

building materials; committees; fire tests; flashover; room fires; standards; building fires; 21118.

building materials; concrete; evaluation; in-place testing; inspection; nondestructive testing; quality assurance; *J. Res. 87(5)*: 407-438; 1982 September-October.

building materials; fire resistance; fire tests; international; ISO; standards; Technical Advisory Group; ASTM; 21139.

building materials; fire tests; flame attachment; heat flux; ignition; room fires; wall coverings; *NBSIR 82-2503*.



- building pipe drains; low water usage devices; pitch of the pipe; plumbing drainage system; plumbing fixtures; transport mechanisms; transport phenomena; wall friction; *SP624*; 1982 June. 293-326.
- building regulations; buildings; energy; enforcement; health and safety; passive design; solar energy; standards; *NBSIR 82-2554*.
- building rehabilitation guidelines; code enforcement; earthquake requirements; energy conservation; existing buildings; rehabilitation; building accessibility; *21385*.
- building research; building technology; codes; criteria; measurement methods; performance criteria; project summaries; technical bases; *SP446-6*.
- building research; equipment research; fire research; geotechnical research; illumination; structural research; thermal performance; *20896*.
- buildings; cooling; heating; hot water; performance criteria; solar energy; standards; *21082*.
- buildings; energy; enforcement; health and safety; passive design; solar energy; standards; building regulations; *NBSIR 82-2554*.
- building subsystem energy criteria; energy conservation in lighting; general lighting; illumination energy; lighting energy; task lighting; building energy performance; *21042*.
- building systems; computer; control; heat exchanger; modeling; monitoring; research; steam; thermal response; valve; air conditioning; *21048*.
- building systems; computer; control; modeling; office building; thermal response; ventilation; air conditioning; air distribution; *21047*.
- building technology; Center for Building Technology; key words; publications; abstracts; *SP457-6*.
- building technology; codes; criteria; measurement methods; performance criteria; project summaries; technical bases; building research; *SP446-6*.
- building technology; construction; Department of Defense; Tri-Services Committee; building materials; *21039*.
- building thermal mass; dynamic performance of buildings; energy conservation; heat transfer in buildings; night space cooling; night ventilation; passive solar heating; *BSS137*.
- building thermal performance; HVAC systems; building control strategies; building energy conservation; *NBSIR 82-2580*.
- Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; *SP640*; 1982 October. 235-254.
- built-up roofing; insulation; moisture; roofing; thermal conductance; thermal conductivity; thermal resistance; *21354*.
- bulk material; laboratory evaluation; optical method; sprayed insulation; asbestos; *SP619*; 1982 March. 44-52.
- bulk modulus; elastic constants; low-temperature; magnetic transition; physical properties; Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus; *21198*.
- bulk standards; construction materials; health risk; polarized light microscopy; asbestos; *SP619*; 1982 March. 34-43.
- bulletproof glass; glazing materials; transparent armor; armor; ballistic protection; ballistic resistant materials; *20910*.
- bulletproof helmets; head protectors; armor; ballistic helmets; ballistic impact; ballistic threat levels; *20913*.
- buoyancy; cross-correlation; diffusion flames; entrainment; heat flux; radiation; turbulence; *NBSIR 82-2473*.
- buoyancy; diffusion flames; flame research; heat flux; methane; *NBS-GCR-82-367*.
- buoyant convection; finite difference computations; fire-enclosure; fluid flow; Lanczos smoothing; partial differential equations; stream function; vorticity; *J. Res. 87(2)*: 165-185; 1982 March-April.
- Burgers vector; defect; dislocation; glide; inclusion; kink; tetragonal; *20973*.
- buried electromagnetic enclosures; electromagnetic compatibility measurements (EMC); low-Q chambers; reverberation chambers; transverse electromagnetic cells; *21061*.
- burner fuel; fuel oil; petroleum; petroleum testing; processed used oil; recycled oil; *21394*.
- burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; residential furnaces; room temperature; thermal response factors; thermostat control; *20903*.
- Burnett method; equation of state; ethylene; helium; saturation density; vapor phase; virial coefficients; *21228*.
- burning rate; compartment fires; flammability regulations; flashover; furniture flammability; room fire tests; *21089*.
- business driver; key volume indicator; materials logistics; *SP500-95*; 1982 October. 127-133.

## C

- cable assembly; cable connector; control cable; control head; D-subminiature connector; interchangeability; law enforcement; microphone cable; mobile transceiver; performance standard; *20904*.
- cable assembly; fatigue; stability; storage coil; superconductor; useful life; *21214*.
- cable attenuation; Fast Fourier Transforms; high speed transient digitizers; pulsed power generators; *SP628*; 1982 June. 381-391.
- cable connector; control cable; control head; D-subminiature connector; interchangeability; law enforcement; microphone cable; mobile transceiver; performance standard; cable assembly; *20904*.
- cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; *NBSIR 82-2501*.
- cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; *NBSIR 82-2528*.
- cables; dc fields; high voltage; incipient fault; insulation; SF<sub>6</sub>; space charge; transformer oil; *NBSIR 82-2586*.
- cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; aluminum point; *SP260-77*.
- cadmium sulfide; chloride-doped cadmium sulfide; chlorine; hydrogen peroxide; ion chromatography; sulfur; *20859*.
- calcium-aluminum hydrates; calorimetry; dehydration; energy storage; rehydration; solar; *NBSIR 82-2531*.
- calcium carbonates; calcium oxalates; calcium phosphates; calcium pyrophosphate; crystal structures; hydroxyapatite; octacalcium phosphate; sodium utate; biomaterials; *21110*.
- calcium oxalates; calcium phosphates; calcium pyrophosphate; crystal structures; hydroxyapatite; octacalcium phosphate; sodium utate; biomaterials; calcium carbonates; calcium oxalates; *21110*.
- calcium pyrophosphate; crystal structures; hydroxyapatite; octacalcium phosphate; sodium utate; biomaterials; calcium carbonates; calcium oxalates; calcium phosphates; *21110*.
- calculated radiation parameters; polarization; standard antennas; VHF-UHF frequency range; wavelength-size scalar horns; antenna directivity pattern; antenna measurements; *21222*.
- calibrated and guarded hot boxes; interlaboratory round robin tests; thermal conductance of building sections; ASTM C-236; *NBSIR 81-2443*.
- calibration; calibration traceability; dynamic standards; transport standards; automatic test equipment; *21025*.
- calibration; californium; dose equivalent; dosimeter; neutron; remmeter; room return; air scatter; *SP633*.
- calibration; californium neutrons; personnel monitoring; reflected neutrons; scattered neutrons; background; *20966*.
- calibration; CCVT; EHV substations; error sources; high voltage measurements; revenue metering; *NBSIR 81-2360*.
- calibration; certification; mass spectrometry; method 1018.2; quantitative analysis; water vapor; *SP400-72*; 1982 April. 39-48.
- calibration; cesium-137; dosimetry standards; iodine-125; iridium-192; radium; standards; brachytherapy; *21311*.
- calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; software; sorption; water; algorithms; *SP400-72*; 1982 April. 3-7.
- calibration; computer; hardware; measurement; third generation ATE; third generation core system; ATE systems; *SP640*; 1982 October. 222.
- calibration; continuum; irradiance; plasma; rare-earth; absolute; *21016*.
- calibration; critically evaluated data; crystallographic data; experimental melting curves; high pressure; high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; *JPCRD 11(4)*: 1005-1064; 1982.
- calibration; curve-fitting; statistics; uncertainty limits; *20800*.



calibration; definitions; hierarchy of standards; National Bureau of Standards; radiation; standards; traceability; *SP609*; 1982 February. 11-17.

calibration; differential manometer; piston gage; pressure difference; pressure transducer; standards; *TN1052*.

calibration; differential pressure; volume; volumetric test measures; water calibration; accountability tank; *TN1158*.

calibration; digitizers; waveform calibration; waveform recording system; waveforms; *SP634*; 1982 June. 35-46.

calibration; dosimetry; environmental; intercomparison; standards; thermoluminescence; *SP609*; 1982 February. 111-116.

calibration; electron beam; high energy; ionization chamber; photon beam; radiation therapy; absorbed dose; *20894*.

calibration; electrons; instrumentation; photon detectors; *SURF-II*; *21053*.

calibration; electro-optical measurements; frequency response; interferometric measurements; Kerr effect; Pockels effect; polarization; accuracy; *SP628*; 1982 June. 1-19.

calibration; environment; natural material; radioactivity; radionuclide; standard; traceability; *SP609*; 1982 February. 117-127.

calibration; field instruments; national radiation standards; radiation therapy; *SP609*; 1982 February. 81-88.

calibration; inertial confinement fusion studies; pulse generators; Antares; *SP628*; 1982 June. 320.

calibration; instruments; measurements; standards; traceability; x ray; *SP609*; 1982 February. 59-64.

calibration; intercomparisons; measurements; radioactivity; standards; system; *SP609*; 1982 February. 31-37.

calibration; ionizing radiation; measurement; national standards; quality assurance; standard reference material; traceability; *SP609*; 1982 February. 45-58.

calibration; leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; radiography; standards; traceable measurements; visual testing; acoustic emission; *21398*.

calibration; measurement; metrology; pressure; pressure scale; standards; *20988*.

calibration; measurement; quality assurance; radon; standards; *20834*.

calibration; measurement assurance; measurement assurance programs; reference standards; standard capacitors; standard qualification; transfer standards; *TN1162*.

calibration; measurement assurance; measurement services; standards; traceability; *SP250*, 1982 Edition.

calibration; measurement assurance; reference standards; standard capacitors; standard qualification; *TN1161*.

calibration; measurements; radiation; radon; radon progeny; standards; states; thoron; *NBS-GCR-82-394*.

calibration; neutrons; standardization; *SP609*; 1982 February. 39-43.

calibration; polarimetry; standards; *21127*.

calibration; reference waveform generators; rise time; time domain measurements; transfer standards; transition duration; waveform generation; waveform measurements; *SP634*; 1982 June. 69-88.

calibration; traceability; ATE; *21028*.

calibration accuracy; laser calibration; LNG ship tanks; photogrammetry; volume calibration; *NBSIR 81-1655*.

calibration instruments; calibrations; calibration techniques; standards; traceability; *SP609*; 1982 February. 67-75.

calibration of gamma-ray detector efficiencies; emission-rate measurements; gamma-ray spectrometry; germanium-detector efficiencies; long-lived-mixed radionuclide standard; uncertainties in gamma-ray measurements; *20874*.

calibration procedures; calibration pulsers; BLACKJACK 5 pulse generator; *SP628*; 1982 June. 150-164.

calibration pulsers; BLACKJACK 5 pulse generator; calibration procedures; *SP628*; 1982 June. 150-164.

calibrations; calibration techniques; standards; traceability; calibration instruments; *SP609*; 1982 February. 67-75.

calibrations; capacitance-current; dielectric; high voltage pulser; pulse generators; voltage probes; *SP628*; 1982 June. 59-68.

calibrations; codes of practice; ionizing radiation; regulations; standards; traceability; type testing; *SP609*; 1982 February. 19-27.

calibrations; instruments; ionizing radiation; measurements; measurement support system; quality assurance; standards; traceability; *SP609*; 1982 February. 3-10.

calibrations; ionizing radiation; measurements; national standards; quality assurance; secondary standard laboratory; traceability; *SP609*.

calibrations; near-field measurements; standard antennas; antenna gain; antenna measurements; antenna pattern; antenna polarization;

21200.

calibrations; reflection errors; anechoic chamber; *20898*.

calibration services; documentation; Measurement Assurance Programs; measurement quality control; metrology management; special tests; *20925*.

calibration techniques; standards; traceability; calibration instruments; calibrations; *SP609*; 1982 February. 67-75.

calibration traceability; dynamic standards; transport standards; automatic test equipment; calibration; *21025*.

californium; dose equivalent; dosimeter; neutron; remmeter; room return; air scatter; calibration; *SP633*.

californium neutrons; personnel monitoring; reflected neutrons; scattered neutrons; background; calibration; *20966*.

calorific value; enthalpy of combustion; estimation from composition; gaseous fuel mixtures; heating value; hydrocarbon gases; ideal gas; real gas; reference measurement conditions; *NBSIR 82-2401*.

calorific value; flow calorimetry; kilogram-size samples; municipal solid waste; refuse-derived fuel; sample characterization; sample variability; *NBSIR 82-2491*.

calorimeter; cavity ionization chamber; extrapolation chamber; free-air chamber; ionizing radiation; measurement standards; radiation dosimetry; standards; *SP609*; 1982 February. 29-30.

calorimeter; convection; heat defect; radiation chemistry; thermistor; water; absorbed dose; *J. Res. 87(3)*: 211-235; 1982 May-June.

calorimeter; polyethylene film; thermistor; water calorimeter; absorbed dose; adiabatic; *U.S. Patent 4,312,224*.

calorimeters; correlation; energy transfer; fire tests; flame spread; ignition; mass loss; test methods; *NBSIR 82-2536*.

calorimeters; fire tests; heat release rate; oxygen consumption; room fires; *NBSIR 81-2427-1*.

calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; radiochromic dye; alanine; biographic interferometry; *20889*.

calorimetry; dehydration; energy storage; rehydration; solar; calcium-aluminum hydrates; *NBSIR 82-2531*.

calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; *SP609*; 1982 February. 171-178.

calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; *20974*.

calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; *20930*.

calorimetry; Fourier equation; radiative cooling; specific heat; thermal diffusivity; *J. Res. 87(6)*: 513-526; 1982 November-December.

CAMAC pulse processing modules; inertial confinement fusion; Sandia Particle Beam Fusion Accelerator; SuperMite; *SP628*; 1982 June. 325-340.

capacitance; cooling rate; dew point; leakage current; *SP400-72*; 1982 April. 98-104.

capacitance-current; dielectric; high voltage pulser; pulse generators; voltage probes; calibrations; *SP628*; 1982 June. 59-68.

capacitance sensing; electronic balance; feedback control; fluid density; hydrostatic weighing; magnetic suspension; *21207*.

capacitance-voltage; electron devices; ellipsometric; integrated circuits; aluminum-oxide interlayer; Auger; *20827*.

capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; *NBSIR 81-2413*.

capacity; dam; lock; queue; simulation; waiting time; *NBSIR 81-2411*.

capacity assignment; computer communication network; tree topology; algorithm; *SP500-95*; 1982 October. 173-182.

capacity divider; high voltage divider; pulse voltage monitor; voltage monitor; waterline voltage monitor; *SP628*; 1982 June. 20-25.

capacity management; computer performance evaluation; Navy nontactical data processing; performance management strategy; *SP500-95*; 1982 October. 65-74.

capacity planning; central server; disk; main memory contention; modeling; packet switch; performance evaluation; simulation; trunk; WIN; analytical; *SP500-95*; 1982 October. 97-106.

capacity planning; chargeback systems; computer performance management systems; queueing models; resource measurement



facilities; simulation; supercomputers; workload characterization; benchmarking; *SP500-95*.

capacity planning; computer performance; modeling; models; software monitors; analytic modeling; *SP500-95*; 1982 October. 81-84.

capacity planning; job accounting; resource management; statistical analysis; workload characterization; *SP500-95*; 1982 October. 259-273.

capitalization practices; database; orthography; bibliographic citations; *SP500-94*; 1982 October. 215-218.

carbamazepine; crystal structure; molecular structure; USP reference standard; x-ray diffraction; analgesic; anticonvulsant; azepine ring; 21298.

carbene; hydroxyl; laser chemistry; laser excited fluorescence; molecular spectroscopy; multiphoton chemistry; 21391.

carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidoxo; 21254.

carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidoxo; 21255.

carbide precipitation; decarburization zones; implantment by mechanical inclusion; macro-molecular clustering; molybdenum disulphide imbedment; *SP640*; 1982 October. 187-193.

carbocyclic compound; cyclic sulfide; ozone; vapor phase reaction; *U.S. Patent 4,327,233*.

carbodiimide; degradation; hydrolysis; kinetics; polyester; polyurethane; acid; 20972.

carbon; carbon monoxide; chemisorption; dissociation; rhodium; 20962.

carbonaceous gases and particles; carbon cycle; chemical selectivity; climate; low-level counting; radiocarbon; accelerator mass spectrometry; atmospheric pollution; 21041.

carbonates, cerium-yttrium, coprecipitation of; ceramics, ceria-yttria, high-density; ceramics, ceria-yttria, hot-pressing of; cerium dioxide, yttrium-doped; cerium-yttrium oxide ceramic; cerium-yttrium oxide powders; homogeneous solution, precipitation from; lattice constant of yttrium-doped cerium dioxide; 21051.

carbon cycle; chemical selectivity; climate; low-level counting; radiocarbon; accelerator mass spectrometry; atmospheric pollution; carbonaceous gases and particles; 21041.

carbon diselenide; infrared; molecular structure; spectroscopy; vibrational spectra; bond distances; 20801.

carbon monoxide; carboxyhemoglobin; cardiovascular disease; fire fatalities; hydrogen cyanide; alcohol; 20812.

carbon monoxide; catalytic activity; dissociation; hydrogen; iron; Ni(100); 20987.

carbon monoxide; chemisorption; dissociation; rhodium; carbon; 20962.

carbon monoxide; chemisorption; isotopic exchange; nickel; temperature programmed desorption; 20863.

carbon monoxide; cigarettes; fatalities; fire; heart disease; heavy metals; hydrogen chloride; scenario; alcohol; 20858.

carbon monoxide; compartment fires; smoldering; building fires; *NBSIR 82-2556*.

carbon monoxide on Ni(111); electron stimulated desorption; ESDIAD; low energy electron diffraction; thermal desorption; adsorption; 21100.

carbonyl sulfide; diode laser spectra; heterodyne frequency measurements; infrared spectroscopy; rotational constants; band centers; 20852.

carbonyl sulphide; intensities; microwave transitions; rotational transitions; absorption coefficients; *JPCRD 11(1)*: 101-117; 1982.

carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; *NSRDS-NBS70*.

carboxyhemoglobin; cardiovascular disease; fire fatalities; hydrogen cyanide; alcohol; carbon monoxide; 20812.

carboxyhemoglobin; fatalities; hydrogen cyanide; polymer; toxicity; autopsy; biological; 20811.

cardiovascular disease; fire fatalities; hydrogen cyanide; alcohol; carbon monoxide; carboxyhemoglobin; 20812.

carrier depth distributions; differential capacitance-voltage profiling; ion implantation; ranges of application and limitations; Schottky barrier diodes; SIMS and C-V profile comparisons; automatic C-V profiler analyses; *SP400-71*.

carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; throughput; transition matrix; *SP500-95*; 1982 October. 365-373.

case study; documentation; documentation guidelines; documentation organizations; documentation procedures; structured interview; technical writing; *SP500-94*; 1982 October. 143-151.

Casino Facility; effects simulator; nuclear weapons; bremsstrahlung radiation; *SP628*; 1982 June. 118-132.

cast steels; fatigue crack growth rates; fracture analysis; mechanical testing; microstructure; rail vehicles; SEM fractography; *SP621*; 1982 October. 33-45.

cataclysmic variables; compact binary x-ray sources; gravitational radiation decay of binary orbits; binary stellar evolution; 21010.

catalysis; chemiluminescence; CO; oxidation; platinum surface; 20821.

catalysts; correlation; dispensancy; engine sequence tests; hot tube; laboratory bench tests; oxidation; solubilization; automotive crankcase oils; bench test procedures; 21279.

catalytic activity; dissociation; hydrogen; iron; Ni(100); carbon monoxide; 20987.

cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; 21326.

cation exchange resin-loaded filters; environmental samples; ultratrace analysis; x-ray spectrometry; 21364.

caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); *SP640*; 1982 October. 235-254.

cavity; equivalence principle; field distribution; slot; aperture; *NBSIR 82-1659*.

cavity current monitors; current measurements; current viewing resistors; high di/dt particle beam accelerator; Rogowski coils; *SP628*; 1982 June. 266.

cavity ionization chamber; extrapolation chamber; free-air chamber; ionizing radiation; measurement standards; radiation dosimetry; standards; calorimeter; *SP609*; 1982 February. 29-30.

cavity phase shift; cesium clock; frequency standard evaluation; frequency standard uncertainties; NBS-6; primary standard; 21251.

Ca XV; Cl XII; energy levels; K XIV; Sc XVI; Ti XVII; wavelengths; V XVIII; 21393.

Ca<sub>2</sub>; charge density; electronic spectra; predissociation; transition probability assignment; 21310.

CCVT; compact; field calibration; high accuracy; modular capacitive divider; portable system; truck-mounted; 21287.

CCVT; EHV substations; error sources; high voltage measurements; revenue metering; calibration; *NBSIR 81-2360*.

CCVTs; EHV revenue metering; energy metering; field calibration; metering accuracy CCVTs; 500 kV; 500 kV substation measurements; *TN1155*.

Ce; energy levels; Eu; Gd; Ho; Nd; Pr; Sm; Tb; wavelength; 20877.

ceiling entrainment; fire flame length; plume fires; 21094.

ceilings; charring; compartment fires; corridors; flame spread; polymers; room fires; thermal degradation; *NBS-GCR-82-377*.

ceilings; compartment fires; computer programs; fire growth; fire models; heat flux; mathematical models; walls; aircraft compartments; aircraft fires; *NBS-GCR-82-404*.

ceilings; diffusion flames; entrainment; fire plumes; flame size; flame structure; room fires; *NBS-GCR-82-402*.

ceilings; fire models; fire plumes; heat transfer; radiation; turbulence; *NBS-GCR-81-304*.

ceiling systems; hazard analysis; hospitals; interstitial space; mattresses; smoke control; smoke exhaust; smoke movement; ventilation systems; *NBSIR 81-2444*.

celestial mechanics; Fourier series; lunar theory; satellite theory; 21030.

celestial mechanics; orbit calculations; algebra of series; 20806.

celestial mechanics; resonances; satellite theory; algebra by computer; Birkhoff normalisation; 20777.

cellular growth; electron beam; interface velocity; rapid solidification; stability; surface melting; aluminum-silver alloys; 21263.

cellulose; combustion; flame; inhibition; inorganic; powder; pyrolysis; retardant; smolder; thermogram; 20799.

cellulosic insulation; Florida; Georgia; newspaper recovery; North



Carolina; resource recovery; South Carolina; *NBS-GCR-82-371*.  
Center for Building Technology; key words; publications; abstracts; building technology; *SP457-6*.  
central air conditioners; heat pumps; rating procedure; seasonal cost of operation; test method; *NBSIR 81-2434*.  
central heating equipment; cooling; heating; heating seasonal performance; heating seasonal performance factor; heat pumps; test method; water source heat pumps; *NBSIR 81-2287*.  
central server; disk; main memory contention; modeling; packet switch; performance evaluation; simulation; trunk; WIN; analytical; capacity planning; *SP500-95*; 1982 October. 97-106.  
central utility plant; diesel engine performance; engine-generator efficiency; environmental impact; heat recovery; total energy system; absorption chillers; boiler performance; *NBSIR 82-2474*.  
ceramic crack detection; ceramic cracks; ceramic fissures; crack detection; fissure detection; fissures; vapor crack detection; *SP400-72*; 1982 April. 201-211.  
ceramic cracks; ceramic fissures; crack detection; fissure detection; fissures; vapor crack detection; ceramic crack detection; *SP400-72*; 1982 April. 201-211.  
ceramic fissures; crack detection; fissure detection; fissures; vapor crack detection; ceramic crack detection; ceramic cracks; *SP400-72*; 1982 April. 201-211.  
ceramic fracture test; crack growth of ceramics; four-point bend test; fracture test; initial value problem; load-displacement characteristics; power-law crack growth; *NBSIR 82-2504*.  
ceramics, ceria-yttria, high-density; ceramics, ceria-yttria, hot-pressing of; cerium dioxide, yttrium-doped; cerium-yttrium oxide ceramic; cerium-yttrium oxide powders; homogeneous solution, precipitation from; lattice constant of yttrium-doped cerium dioxide; carbonates, cerium-yttrium, coprecipitation of; *21051*.  
ceramics, ceria-yttria, hot-pressing of; cerium dioxide, yttrium-doped; cerium-yttrium oxide ceramic; cerium-yttrium oxide powders; homogeneous solution, precipitation from; lattice constant of yttrium-doped cerium dioxide; carbonates, cerium-yttrium, coprecipitation of; ceramics, ceria-yttria, high-density; *21051*.  
Cerdip; Cerpak; leak detection; mass spectrometry; Method 1018; moisture sensors; surface conductivity sensors; aluminum oxide sensors; *SP400-72*; 1982 April. 90-97.  
Cerdip; glass sealed; integrated circuit; packages; quality control; thermal shock; *SP400-72*; 1982 April. 234-238.  
Cerdip; integrated circuit packaging; internal water vapor; moisture evolution; package reliability; sealing glass; *SP400-72*; 1982 April. 220-233.  
Cerdip packages; IC assembly; in-situ moisture sensors; LSI circuits; mass spectrometry; on-going monitoring activity; package-sealing environment; aluminum oxide; *SP400-72*; 1982 April. 113-116.  
Cerdips; desorption; mass spectrometry; moisture evolution analysis; water sorption phenomenon; *SP400-72*; 1982 April. 213-219.  
ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; luminescence; radiochromic dye; alanine; biographic interferometry; calorimetry; *20889*.  
cerium dioxide, yttrium-doped; cerium-yttrium oxide ceramic; cerium-yttrium oxide powders; homogeneous solution, precipitation from; lattice constant of yttrium-doped cerium dioxide; carbonates, cerium-yttrium, coprecipitation of; ceramics, ceria-yttria, high-density; ceramics, ceria-yttria, hot-pressing of; *21051*.  
cerium-yttrium oxide ceramic; cerium-yttrium oxide powders; homogeneous solution, precipitation from; lattice constant of yttrium-doped cerium dioxide; carbonates, cerium-yttrium, coprecipitation of; ceramics, ceria-yttria, high-density; ceramics, ceria-yttria, hot-pressing of; cerium dioxide, yttrium-doped; *21051*.  
cerium-yttrium oxide powders; homogeneous solution, precipitation from; lattice constant of yttrium-doped cerium dioxide; carbonates, cerium-yttrium, coprecipitation of; ceramics, ceria-yttria, high-density; yttrium-doped; cerium-yttrium oxide ceramic; *21051*.  
Cerpak; leak detection; mass spectrometry; Method 1018; moisture sensors; surface conductivity sensors; aluminum oxide sensors; Cerdip; *SP400-72*; 1982 April. 90-97.  
certification; functions; laboratory accreditation; product certification; system operation; accreditation; *SP632*; 1982 March. 24-27.  
certification; mass spectrometry; Method 1018; quantitative analysis; standards; water vapor; *SP400-72*; 1982 April. 32-38.  
certification; mass spectrometry; method 1018.2; quantitative analysis; water vapor; calibration; *SP400-72*; 1982 April. 39-48.  
certifiers; evaluation; International Electrotechnical Commission; laboratory; test facilities; *SP632*; 1982 March. 74-75.  
cesium; frequency standards; lasers; metrology; spectroscopy; atomic beams; *21252*.  
cesium clock; frequency standard evaluation; frequency standard uncertainties; NBS-6; primary standard; cavity phase shift; *21251*.  
cesium-137; dosimetry standards; iodine-125; iridium-192; radium; standards; brachytherapy; calibration; *21311*.  
CF<sub>2</sub>CFCl; infrared excitation; multiphoton dissociation; product state distributions; review infrared multiphoton dissociation; CF<sub>2</sub>HCl; *21334*.  
CF<sub>2</sub>HCl; CF<sub>2</sub>CFCl; infrared excitation; multiphoton dissociation; product state distributions; review infrared multiphoton dissociation; *21334*.  
CF<sub>2</sub>HCl (chlorodifluoromethane); induction times; infrared laser; intensity dependence in infrared photochemistry; laser chemistry; laser excited fluorescence; multiphoton dissociation; unimolecular dissociation rates; *21342*.  
CH; far infrared; hyperfine constants; lambda doubling; laser magnetic resonance; rotational levels; Zeeman effect; *21273*.  
chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion; *21395*.  
chain folding; crystallization of polymers; lamellae; *21280*.  
chain folding in polymers; copolymer; phase transition in polymers; polymer crystals; block copolymers; *21066*.  
chain saw kickback motion; displacement measurements; kickback energy; optoelectronic measurement system; simulated kickback motion; volunteer test subjects; *NBSIR 82-2559*.  
chairs; compartment fires; fire tests; flammability; furnishings; upholstered furniture; *21092*.  
channel access; load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; throughput; transition matrix; carrier sense multiple access; *SP500-95*; 1982 October. 365-373.  
channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); *FIPS PUB 61-1*.  
characteristics; door security; entry control; hardware; installation; locking device classification; lock operation; *NBSIR 81-2233*.  
characterization; sources; asbestos; asbestos analysis; asbestos standards; *SP619*; 1982 March. 5-20.  
character shapes; data entry; Federal Information Processing Standard; graphic shapes; magnetic ink characters; MICR; MICR Read Optically; OCR; optical character recognition; *FIPS PUB 32-1*.  
chargeback systems; charging systems; cost accounting; costing; DP accounting; pricing; billing systems; *SP500-95*; 1982 October. 425.  
chargeback systems; computer performance management systems; queueing models; resource measurement facilities; simulation; supercomputers; workload characterization; benchmarking; capacity planning; *SP500-95*.  
charge density; electronic spectra; predissociation; transition probability assignment; Ca<sub>2</sub>; *21310*.  
charge distribution; computer analysis; data reduction; Fourier analysis; piezoelectric polymers; polarization distribution; thermal pulse experiment; *21155*.  
charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; *NBSIR 81-2413*.  
charge magnetization; Coulomb sum rule; electron scattering; Fermi gas model; nuclear response function; nuclei; nucleons; quasi-free; *21400*.  
charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; *NBSIR 81-2413*.  
charge recombination; cyclopentane; photofragmentation; photoionization; quantum yields; radiation chemistry; vacuum ultraviolet; *21243*.  
charge relay; enzymes; protein structure; ribonuclease; x-ray diffraction; active site; *20893*.  
charge to mass ratio; energy resolved emittance; energy spectrum; Thomson spectrometer; *SP628*; 1982 June. 257-265.  
charge-transfer; corrosion; electrochemistry; frequency analysis;



rectification; alternating voltage; 20886.

charge transfer; hybridization; isomer shift; Mössbauer effect; alloying; alloy phase diagrams; 20820.

charge transfer spectrum; electron impact ionization; ionization potential; photoelectron spectroscopy; photoionization; spectroscopy; appearance potential; *NSRDS-NBS71*.

charge transport; copolymer; electrical properties; piezoelectricity; poling; pyroelectricity; tetrafluoroethylene; vinylidene fluoride; 20840.

charging systems; cost accounting; costing; DP accounting; pricing; billing systems; chargeback systems; *SP500-95*; 1982 October. 425.

charring; compartment fires; corridors; flame spread; polymers; room fires; thermal degradation; ceilings; *NBS-GCR-82-377*.

check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; aluminum point; cadmium point; *SP260-77*.

cheek plate tamper resistance; salt spray corrosion resistance; warded lock; ace type pin tumbler lock; 21199.

chemical analysis; conductance; pH; precipitation; rain; reference materials; trace elements; acidity; acid rain; *NBSIR 82-2581*.

chemical analysis; digital periodic integrator; electron probe microanalysis; glass standards; homogeneity testing; microhomogeneity; mineral glasses; standard reference material; *SP260-74*.

chemical analysis; electrochemistry; membranes; olfaction; protein separation; *NBS-GCR-82-378*.

chemical analysis; sampling; sampling atmospheres; sampling food; sampling miscellaneous materials; sampling plan; sampling water; *TN1153*.

chemical blank; contamination control; leachates; leach testing; nuclear waste; trace elements. nuclear waste; trace elements; 21372.

chemical characterization; data compilation; dielectric properties; electrical properties; mechanical properties; thermal properties; thermodynamic properties; thermophysical properties; basal; *NBSIR 82-2587*.

chemical composition; fibers; glass; physical dimensions; analytical standards; asbestos standards; *SP619*; 1982 March. 21-28.

chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; radiochromic dye; alanine; bioluminescence; calorimetry; ceric-cerous dosimetry; 20889.

chemical engineering; facilitated transport; liquid membrane; membrane; purification; separation; 21241.

chemical industry trends/strategies; commodity organic chemicals; measurement/evaluated data needs; NBS research capabilities; biomass conversion R&D; bioprocess engineering; biotechnology; *NBSIR 82-2549*.

chemical interactions; deep-level measurements; defects; optical properties; silicon; sulfur; 20842.

chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; *NSRDS-NBS72*.

chemical kinetics; data evaluation; gas phase; photo-absorption cross section; photochemistry; quantum yield; rate coefficient; air pollution; atmospheric chemistry; *JPCRD 11(2)*: 327-496; 1982.

chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; *NSRDS-NBS70*.

chemical kinetics; flash photolysis; hydroxyl radicals; nitric acid; rate constant; resonance fluorescence; stratospheric ozone; 21040.

chemical kinetics; oxidation; oxygen; sulfite ion; sulfur dioxide; aqueous solution; bibliography; bisulfite ion; *SP630*.

chemical kinetics solution; kinetic titrimetry; ordinary differential equation solution; parabolic cylinder functions; titration; 20912.

chemical properties; critical tables; data evaluation; physical properties; reference data; 21389.

chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; software; sorption; water; algorithms; calibration; *SP400-72*; 1982 April. 3-7.

chemical selectivity; climate; low-level counting; radiocarbon; accelerator mass spectrometry; atmospheric pollution; carbonaceous gases and particles; carbon cycle; 21041.

chemical thermodynamics; enthalpy; entropy; evaluated data; Gibbs energy; inorganic chemistry; thermochemistry; *JPCRD 11(Suppl. 2)*: 394 pp.; 1982.

chemiluminescence; CO; oxidation; platinum surface; catalysis; 20821.

chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review; additives; antioxidants; basestocks; *NBSIR 82-2490*.

chemisorption; dissociation; halocarbon; halogen; iron; adsorption; 21154.

chemisorption; dissociation; rhodium; carbon; carbon monoxide; 20962.

chemisorption; hydrogen; hydrogen deuterate; kinetic isotope effect; transition state; zinc oxide; 20971.

chemisorption; hydrogen; neutron inelastic scattering; Raney nickel; vibrational spectroscopy; 21295.

chemisorption; isotopic exchange; nickel; temperature programmed desorption; carbon monoxide; 20863.

chevre-phase;  $\text{ErRh}_4\text{B}_4$ ; ferromagnetic superconductors; neutron scattering; ternary superconductors; antiferromagnetic superconductors; 21131.

chimneys; creosote; fire safety; fire tests; flues; heating equipment; stoves; wood; *NBS-GCR-82-368*.

chimneys; creosote; fire safety; flues; heating equipment; stoves; tar; temperature measurements; wood; *NBS-GCR-81-365*.

chimneys; fire tests; flues; heating equipment; literature reviews; radiant energy; stoves; wall protection; walls; wood; *NBSIR 82-2506*.

chloride-doped cadmium sulfide; chlorine; hydrogen peroxide; ion chromatography; sulfur; cadmium sulfide; 20859.

chlorinated benzenes; chlorinated dioxins; chlorinated phenols; estimation; heats of formation; procedure; 21346.

chlorinated dioxins; chlorinated phenols; estimation; heats of formation; procedure; chlorinated benzenes; 21346.

chlorinated phenols; estimation; heats of formation; procedure; chlorinated benzenes; chlorinated dioxins; 21346.

chlorine; hydrogen peroxide; ion chromatography; sulfur; cadmium sulfide; chloride-doped cadmium sulfide; 20859.

chlorine-like ions; distorted wave theory; electron ionization; 21367.

chlorine monoxide; ClO; diode laser; infrared; spectra; air pollution; atmospheric chemistry; 21303.

cholesterol analysis; definitive method; isotope dilution/mass spectrometry; mass spectrometry; stable isotope dilution analysis; statistical analysis; total cholesterol analysis; 20796.

chromatography; copolymers; kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; *NBSIR 81-2424*.

chromium; coatings; electrodeposition; metallic glasses; nickel-phosphorus; steel; wear; wear testing; 21232.

chromosphere; Sun; supergranulation; atmospheric motions; 21377.

chronopotentiometry; coefficient; diffusion; electrodes; examination; planar; stationary; unshielded; 21361.

chronometers; Greenwich; Royal Observatory; time ball; time signals; 21024.

chrysotile asbestos; electron microscopy; filter; isooctane; liquid separation; *SP619*; 1982 March. 85-90.

chrysotile asbestos; fiber; glass; mass concentrations; water samples; *SP619*; 1982 March. 121-131.

chrysotile fiber; EPA provisional method; filter; asbestos; asbestos minerals; *SP619*; 1982 March. 190-206.

chrysotile filter; filter homogeneity; Poisson statistical process; statistical methods; analysis; asbestos fibers; *SP619*; 1982 March. 169-182.

C-H stretching region; difference-frequency laser; Doppler-limited resolution; ethane; ground state constants; infrared spectrum; low temperature spectrum; torsional splittings; *J. Res. 87(3)*: 237-256; 1982 May-June.

C-H vibrations; laser photoacoustic spectroscopy; alkanes; alkenes; 21371.

$\text{CH}_3$ ;  $\text{Hg}(\text{CH}_3)_2$ ; laser; photodissociation; 21319.

$\text{CH}_{30}$ ; formaldehyde;  $\text{HNO}$ ; hydrogen bonding; infrared spectrum; matrix isolation; methyl nitrite; photodecomposition; 21301.

$\text{CH}_4$ ; decomposition; heterogeneous catalysis; hydrogen; methanation;  $\text{NH}_3$ ; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); 20825.

cigarettes; codes; escape; fatalities; fire; flaming; flashover; nonresidential; residential; scenario; smoldering; 20775.

cigarettes; fabrics; flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; textiles; upholstered furniture; 21128.

cigarettes; fatalities; fire; heart disease; heavy metals; hydrogen



chloride; scenario; alcohol; carbon monoxide; 20858.

circuit switching; communications networks; distributed control; integrated switching; packet switching survivability; alternate routing; *NBSIR 82-2588*.

clamping; diode recovery; high power measurements; high voltage; overshoot; power semiconductors; reverse-bias second breakdown; testing; voltage; 20849.

clients; international trading; laboratory accreditation; public; analytical laboratories; *SP632*; 1982 March. 46-51.

climate; low-level counting; radiocarbon; accelerator mass spectrometry; atmospheric pollution; carbonaceous gases and particles; carbon cycle; chemical selectivity; 21041.

climatology; extreme winds; fluid mechanics; meteorology; structural engineering; wind; 21212.

clinical analysis; glucose in serum; glucose reference method; isotope dilution/mass spectrometry; reference method; statistical analysis; *SP260-80*.

CIO; diode laser; infrared; spectra; air pollution; atmospheric chemistry; chlorine monoxide; 21303.

close-coupled scattering theory; dressed-atoms; inelastic cross-sections; laser; laser-induced collisions; radiation theory; stimulated emission; atomic collisions; 21347.

close-coupling approximation; CO<sub>2</sub> laser; elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; free-free transitions; Nd laser; photon-assisted transitions; angular distributions; 20787.

clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; thermal comfort; ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; *NBSIR 82-2585*.

clothing wardrobes; health care facilities; hospital mattresses; smoke movement; sprinkler systems; 20793.

clothoids; computer-aided design; Cornu-spirals; curvature; curve fitting; Fresnel-integrals; interpolation; splines; approximation; *J. Res. 87(4)*: 317-346; 1982 July-August.

clusters; coincidence; mass spectrometry; photoelectron spectroscopy; photoionization; Xe; 21153.

clusters; copper; gold; silver; single crystal; thin films; aluminium; 21012.

Cl XII; energy levels; K XIV; Sc XVI; Ti XVII; wavelengths; V XVIII; Ca XV; 21393.

CN; ethynyl; radicals; abstraction reactions; activation energies; bond-energy-bond-order; 20781.

CO; oxidation; platinum surface; catalysis; chemiluminescence; 20821.

coal conversion; coal gasification; corrosion; erosion; materials properties; mechanical properties; physical properties; refractories; alloys; *SP642*.

coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; utility systems; abstracted reports and articles; *SP489, Supplement 1*.

coal gasification; corrosion; erosion; materials properties; mechanical properties; physical properties; refractories; alloys; coal conversion; *SP642*.

coal mines; combustion products; compartment fires; fabric flammability; fire research; fire tests; flame research; smoke; bibliographies; building fires; *NBSIR 82-2499*.

coal slag; conductivity; high temperature; impedance; resistivity; 21182.

coatings; electrodeposition; metallic glasses; nickel-phosphorus; steel; wear; wear testing; chromium; 21232.

coatings; salt-spray test; short-term tests; 21060.

coaxial; communication; contention; data; digital; Ethernet; local; microprocessor; network; serial; broadcast; 20839.

coaxial noise sources; controller; IEEE 488 Bus; total power radiometer; automated noise measurement system; *NBSIR 81-1656*.

cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; survey; teletherapy; thermoluminescence dosimetry; traceability; *SP609*; 1982 February. 89-97.

cobalt-60 gamma rays; Compton scatter; fluence scaling; graphite phantom; ionization chamber; water phantom; 21055.

COBOL analyzer; automated software testing tools; Automated Verification System; *SP500-95*; 1982 October. 51-60.

CODASYL; database management system; DBMS; network data model; access control; *NBS-GCR-82-370*.

code enforcement; earthquake requirements; energy conservation; existing buildings; rehabilitation; building accessibility; building rehabilitation guidelines; 21385.

code provisions; passive solar systems; performance criteria; solar energy; standards; test procedures; 21119.

codes; criteria; measurement methods; performance criteria; project summaries; technical bases; building research; building technology; *SP446-6*.

codes; escape; fatalities; fire; flaming; flashover; nonresidential; residential; scenario; smoldering; cigarettes; 20775.

codes of practice; ionizing radiation; regulations; standards; traceability; type testing; calibrations; *SP609*; 1982 February. 19-27.

code transition levels; converter testing; dynamic testing; high resolution; settling time; step response; analog-to-digital converters; 20908.

coefficient; diffusion; electrodes; examination; planar; stationary; unshielded; chronoamperometry; 21361.

coexistence; ethylene; heat capacity; saturated liquid; specific heat; thermodynamic properties; 21187.

coherency; composites; small particles; solid solutions; strain; surfaces; thermodynamics; 20807.

coherent scattering; cross section; form factor; Rayleigh scattering; tabulation; water; x rays; *JPCRD 11(4)*: 1091-1098; 1982.

coincidence; mass spectrometry; photoelectron spectroscopy; photoionization; Xe; clusters; 21153.

Collaborative Reference Program; paper; TAPPI; tenth anniversary; testing; 21244.

collapse; concrete; concrete strength; construction; cooling tower; failure; hyperbolic shell; shell; *BSS148*.

collapse; concrete; concrete strength; construction; failure; flat plate; shear; strength; building; *BSS145*.

collapse; concrete; construction; failure investigation; falsework; field load tests; formwork; post-tensioning; structural analysis; bridge; *NBSIR 82-2593*.

collapse; connection; construction; failure; steel; walkway; building; *BSS143*.

collapse; cracks; defects; failure; fracture mechanics; girth welds; pipeline; plasticity; strength; stress; toughness; 21169.

collection efficiency; quantum efficiency; quantum yield; silicon photodiode; spectral response; 21396.

collector efficiency; unglazed collector; ASHRAE Standard 96-1980; BSE; *NBSIR 82-2522*.

collector rating; incident angle modifier; measurement; solar collector; standards; thermal performance; uncertainty; 21387.

collectors; solar domestic hot water; solar simulator; standard; test method; ASHRAE 95; 20940.

collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; NBS; solar; solar domestic hot water system; stratification; test method; ASHRAE Standard 95; *BSS140*.

collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; *NBSIR 81-2393*.

collision-induced; far infrared spectra; hydrogen; hydrogen mixtures; rotational transitions; spectra; absorption coefficient; 21165.

collision-induced absorption; collision-induced light scattering; far infrared absorption; induced dipole; line shape; rare gas mixtures; spectra; transient dipoles; 21173.

collision-induced absorption; concentration; correlation function; density; rare gas mixtures; spectral behavior; absorption spectrum; atomic masses; 21007.

collision-induced absorption; potential functions; spectral moments; translational spectrum; wave mechanical lineshapes; argon; binary mixtures; 20929.

collision-induced dipoles; collision-induced spectra; dielectric virial; intermolecular interactions; molecular constants; spectral shape; 21167.

collision-induced light scattering; far infrared absorption; induced dipole; line shape; rare gas mixtures; spectra; transient dipoles; collision-induced absorption; 21173.

collision-induced spectra; dielectric virial; intermolecular interactions; molecular constants; spectral shape; collision-induced dipoles; 21167.

collision integral; kinetic theory; perturbation theory; transport coefficient; transport properties; Boltzmann equation; 21197.

collisions; dielectronic recombination; multicharged ions; scattering; autoionization; 20880.

collision stopping power; electrons; positrons; radiation yield;



radiative stopping power; range; *NBSIR 82-2550*.

colorimetric iron kit; iron; jet engine oil; portable; rapid; wear-metal analysis; *SP640*; 1982 October. 455-465.

combination band; high-resolution; molecular spectroscopy; transition moments; tunable lasers; anharmonicity; *20924*.

combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; *NSRDS-NBS72*.

combustion; degradation; polymers; polystyrene; pyrolysis; radiation flux; *NBS-GCR-82-403*.

combustion; flame; inhibition; inorganic; powder; pyrolysis; retardant; smolder; thermogram; cellulose; *20799*.

combustion aerosols; particle size distribution; smoke; smoke detection; smoke production; smoldering; aerosol coagulation; *21231*.

combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits; *NBSIR 82-2578*.

combustion products; compartment fires; fabric flammability; fire research; fire tests; flame research; smoke; bibliographies; building fires; coal mines; *NBSIR 82-2499*.

combustion products; fire investigation; fire modeling; fire protection; human behavior; smoke control; smoldering; sprinkler systems; toxicity; arson; building design; *SP639*.

combustion products; flaming combustion; inhalation; materials; nonflaming combustion; test method; toxicity; *NBSIR 82-2532*.

comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; *NBSIR 81-2393*.

comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; thermal comfort; ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; *NBSIR 82-2585*.

comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; *NBSIR 81-2393*.

commercial; independent; laboratory accreditation; manufacturing concerns; *SP632*; 1982 March. 57-58.

commercial body armor; performance standards; police body armor; protective undergarments; armor; ballistic protection; ballistic threat; *20906*.

commercial buildings; economic analysis; energy economics; life-cycle costing; solar energy; building economics; *NBSIR 82-2540*.

commercial laboratories; concrete; laboratory accreditation; NVLAP; testing; *SP632*; 1982 March. 54-56.

committees; fire tests; flashover; room fires; standards; building fires; building materials; *21118*.

commodity organic chemicals; measurement/evaluated data needs; NBS research capabilities; biomass conversion R&D; bioprocess engineering; biotechnology; chemical industry trends/strategies; *NBSIR 82-2549*.

communication; contention; data; digital; Ethernet; local; microprocessor; network; serial; broadcast; coaxial; *20839*.

communication; design issues; hazard; pictograms; pictorial; safety; signs; standards; symbols; visual alerting; warning; *BSS141*.

communication protocols; computer network protocols; formal description techniques; protocol specification methods; automatic implementation techniques; *21034*.

communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; standards; *FIPS PUB 93*.

communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cassettes; magnetic tape recording; magnetic tape transports; standards; *FIPS PUB 91*.

communications networks; distributed control; integrated switching; packet switching survivability; alternate routing; circuit switching; *NBSIR 82-2588*.

communications networks; distributed control; message delay; network throughput; survivability; alternate routing; *20994*.

Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization; residential energy consumption; weatherization; *NBSIR 82-2539*.

Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization; residential energy consumption; weatherization; Community Action Agencies; *BSS144*.

Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization; Community Action Agencies; *NBSIR 82-2539*.

Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; weatherization; *TN1156*.

compact; field calibration; high accuracy; modular capacitive divider; portable system; truck-mounted; CCVT; *21287*.

compact binary x-ray sources; gravitational radiation decay of binary orbits; binary stellar evolution; cataclysmic variables; *21010*.

compaction; compaction tests; heat flow; laboratory tests; soil moisture; soil tests; tests; thermal conductivity; thermal resistivity; Atterberg Limit tests; *BSS149*.

compaction tests; heat flow; laboratory tests; soil moisture; soil tests; tests; thermal conductivity; thermal resistivity; Atterberg Limit tests; compaction; *BSS149*.

compact range; planar near-field measurements; precision parabolic reflector; radar cross-section measurements; antenna measurements; *21215*.

comparative measurements; design; dividers; impulse measuring systems; resistor dividers; response time; voltage measurement; *SP628*; 1982 June. 34-45.

comparison of models; linear regression; neutron diffraction; powder refinement; significant differences; statistical analysis; *21401*.

comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; utility systems; abstracted reports and articles; coal-fired MIUS; *SP489, Supplement 1*.

compartment fires; computer programs; fire growth; fire models; heat flux; mathematical models; walls; aircraft compartments; aircraft fires; ceilings; *NBS-GCR-82-404*.

compartment fires; correlations; corridor tests; fire growth; fire tests; flammability; flashover; interior finishes; room fires; *NBSIR 82-2525*.

compartment fires; corridors; flame spread; polymers; room fires; thermal degradation; ceilings; charring; *NBS-GCR-82-377*.

compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; building fires; *21121*.

compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits; combustion products; *NBSIR 82-2578*.

compartment fires; entrainment; fire plumes; flow rates; opening flows; air flows; *NBSIR 82-2520*.

compartment fires; fabric flammability; fire research; fire tests; flame research; smoke; bibliographies; building fires; coal mines; combustion products; *NBSIR 82-2499*.

compartment fires; fire endurance; fire engineering design; liquid pool fires; thermoplastic pool fires; wood crib fires; *21093*.

compartment fires; fire safety; life safety; room fires; sidewall sprinkler systems; thermal response; automatic sprinklers; *NBSIR 82-2521*.

compartment fires; fire tests; flammability; furnishings; upholstered furniture; chairs; *21092*.

compartment fires; flammability regulations; flashover; furniture flammability; room fire tests; burning rate; *21089*.

compartment fires; smoldering; building fires; carbon monoxide; *NBSIR 82-2556*.

compatibility; guidelines; procedures; software; *SP500-94*; 1982 October. 80-83.

compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; *NBSIR 81-2356*.



compilation; efficiency data; half lives; measurement uncertainties; photon probabilities per decay; relative photon-emission probabilities; *SP626*.  
 compilers; dynamic analysis; programming aids; software development; software engineering; software tools; static analysis; *NBSIR 81-2423*.  
 compilers; dynamic analysis; programming aids; software development; software engineering; software tools; static analysis; *NBS-GCR-82-376*.  
 complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; *21272*.  
 compliance sampling; dual acceptance criteria; mixed sampling plan; order statistics; statistical methods; acceptance probability; *J. Res. 87(6): 485-511; 1982 November-December*.  
 components of variance; consensus values; design of experiments; pooling of variance; weighted average; weighted least squares regression; ANOVA (within-between); *J. Res. 87(5): 377-385; 1982 September-October*.  
 composite; dental; instrumentation; pin and disc; restorative; wear; amalgam; apparatus; *20916*.  
 composite inspection; corrosion detection; cost savings; NDE; neutron radiography; preventive maintenance; *SP640; 1982 October. 417-453*.  
 composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; *NBSIR 82-2528*.  
 composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; *NBSIR 82-2501*.  
 composite materials; damage; fatigue; guys; mechanical testing; nondestructive testing; pultrusions; standards; *21195*.  
 composite materials; laminate structure; maintenance; repairability; sandwich structure; testing; *SP640; 1982 October. 364-378*.  
 composite resins; expansion; hardening shrinkage; hygroscopic expansion; polymerization; water sorption; absorption; *21052*.  
 composites; dental resins; fillers; acid etch; BIS-GMA; bonding; *20847*.  
 composites; dental resins; fillers; pedodontics; acid etch; adhesive bonding; *20915*.  
 composites; elastic constants; elastic-wave scattering; fiber-reinforced composites; particulate composites; wave propagation; *20884*.  
 composites; elastic properties; flux deviation; moisture effects; *21196*.  
 composites; small particles; solid solutions; strain; surfaces; thermodynamics; coherency; *20807*.  
 compressibility; density; equation of state; expansivity; Pitzer's equations; *PVT*; volume; volumetric properties; apparent molal volume; aqueous sodium chloride solutions; *JPCRD 11(1): 15-81; 1982*.  
 compressible fluid motion; convection; finite difference approximation; heat transfer; natural convection; nonlinear convection; numerical integration; transient fluid motion; transient heat transfer; *NBSIR 82-1660*.  
 compressive strength; concrete mortar; elongation; low temperature; maximum strength; mechanical properties; yield strength; Young's modulus; *NBSIR 82-1658*.  
 compressive strength; concretes; regression analysis; safety; shear properties; splitting tensile strength; statistical analysis; age-strength relation; building codes; *21150*.  
 Compton scatter; fluence scaling; graphite phantom; ionization chamber; water phantom; cobalt-60 gamma rays; *21055*.  
 computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems; artificial intelligence; automation; *NBSIR 82-2582*.  
 computational method, fluid mechanics; drainage piping; transient pipe flow; transient solid motion, pipe flows; *21081*.  
 computational methods; computer programs; custody transfer; density measurement; density reference standard; liquefied natural gas; *20946*.  
 computer; control; heat exchanger; modeling; monitoring; research; steam; thermal response; valve; air conditioning; building systems; *21048*.  
 computer; control; modeling; office building; thermal response; ventilation; air conditioning; air distribution; building systems; *21047*.  
 computer; hardware; measurement; third generation ATE; third generation core system; ATE systems; calibration; *SP640; 1982 October. 222*.  
 computer accounting; representative workload; system monitoring; workload characterization; workload measurement; *SP500-95; 1982 October. 111-120*.  
 computer-aided design; computer-aided manufacturing; hierarchical control systems; simulation; automated manufacturing; automatic control; *NBS-GCR-82-413*.  
 computer-aided design; computer-aided manufacturing simulation; hierarchical control systems; automated manufacturing; automatic control; *NBS-GCR-82-414*.  
 computer-aided design; computer simulation; emergency egress; fire research; human performance; modeling; pedestrian movement; regulatory process; simulation of human behavior; building codes; building fires; *20911*.  
 computer-aided design; Cornu-spirals; curvature; curve fitting; Fresnel-integrals; interpolation; splines; approximation; clothoids; *J. Res. 87(4): 317-346; 1982 July-August*.  
 computer aided manufacturing; glossary; materials handling; robotics; robots; automation; *NBSIR 81-2340*.  
 computer-aided manufacturing; hierarchical control systems; simulation; automated manufacturing; automatic control; computer-aided design; *NBS-GCR-82-413*.  
 computer-aided manufacturing simulation; hierarchical control systems; automated manufacturing; automatic control; computer-aided design; *NBS-GCR-82-414*.  
 computer aided measurement; laboratory automation; pulse analysis; pulse waveform analysis; waveform analysis; waveform recording; automated oscilloscope; *SP634; 1982 June. 55-67*.  
 computer-aided mechanical tests; cryogenic mechanical properties; fracture (materials); fracture toughness; J-integral; low-temperature tests; stainless steels; *20864*.  
 computer analysis; data reduction; Fourier analysis; piezoelectric polymers; polarization distribution; thermal pulse experiment; charge distribution; *21155*.  
 computer architecture; performance evaluation; performance modeling; queueing models; queueing networks; shared device; *20802*.  
 computer architecture; performance modeling; queueing model; queueing networks; approximate queueing model; *20969*.  
 computer-automated; re-entry vehicles; reliability assessment; automatic test system; *SP640; 1982 October. 216-221*.  
 computer-based applications; data processing; Information Resource Management; productivity; *SP500-95; 1982 October. 19-24*.  
 computer based model; drainage; solid transport; unsteady flow; *BSSI39*.  
 computer communication network; tree topology; algorithm; capacity assignment; *SP500-95; 1982 October. 173-182*.  
 computer control; gas transmission; permeation; permeation time-lag; SRM 1470; standard reference materials; automation; *21026*.  
 computer controlled mechanical test; crack growth; creep-fatigue; mechanical testing; multiaxial tests; stress-corrosion; *21111*.  
 computer crime; computer security; A-123; data processing; *SP500-95; 1982 October. 89-94*.  
 computer environments; software; software engineering; software management; software quality; software tools; toolsmith; *SP500-91*.  
 computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; system parameters; transportable computer software; ANSI FORTRAN; *TN1163*.  
 computer indexing; data base; directory look-up; information retrieval; interactive processing; random access; *TN1167*.  
 computerized analysis; electric utility rate regulation; Experimental Technology Incentives Program; innovation; productivity analysis; *NBSIR 80-2046*.  
 computerized-fingerprint-identification; identification; pattern recognition; *SP500-89*.  
 computer maintained documentation; documentation requirements; integrated design and documentation; *SP500-94; 1982 October. 110-118*.  
 computer model; surge attenuation; unsteady flow; building drainage; *NBSIR 82-2478*.  
 computer models; flame spread; pyrolysis; solid fuels; additives; *NBS-GCR-82-396*.  
 computer network; local networking; mathematical modeling; measurement; network performance; performance evaluation; *SP500-95; 1982 October. 389-396*.



computer network protocols; formal description techniques; protocol specification methods; automatic implementation techniques; communication protocols; *21034*.

computer networks; distributed data; Government and industry; protocol standards; telecommunications; *21265*.

computer networks; Federal Information Processing Standards; International Organization for Standardization; local area networks; National Bureau of Standards; network protocols; standards; *21363*.

computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems; artificial intelligence; automation; computational; *NBSIR 82-2582*.

computer performance; modeling; models; software monitors; analytic modeling; capacity planning; *SP500-95*; 1982 October. 81-84.

computer performance evaluation; Navy nontactical data processing; performance management strategy; capacity management; *SP500-95*; 1982 October. 65-74.

computer performance evaluation; performance improvement plan; system performance indicators; *SP500-95*; 1982 October. 75-80.

computer performance evaluation (CPE); computer performance management (CPM); service levels; user service reporting system (USRS); ADP effectiveness; *NBS-GCR-82-382*.

computer performance management (CPM); service levels; user service reporting system (USRS); ADP effectiveness; computer performance evaluation (CPE); *NBS-GCR-82-382*.

computer performance management systems; queueing models; resource measurement facilities; simulation; supercomputers; workload characterization; benchmarking; capacity planning; chargeback systems; *SP500-95*.

computer performance modeling; computer simulation; local area network; *SP500-95*; 1982 October. 107.

computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); channel level power control interface; *FIPS PUB 61-1*.

computer program; correlation coefficient; outlier; process validation wafer; statistical analysis; two-dimensional arrays; wafer map; *NBSIR 82-2492*.

computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; *NBS-GCR-82-385*.

computer program; database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; software; *NBS-GCR-82-386*.

computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; *NBS-GCR-82-387*.

computer program; database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; software; *NBS-GCR-82-384*.

computer program abstracts; software documentation; standards; information systems; *SP500-94*; 1982 October. 197-202.

computer programs; custody transfer; density measurement; density reference standard; liquefied natural gas; computational methods; *20946*.

computer programs; density; enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; *TN1048*.

computer programs; documentation; Federal Information Processing Standards (FIPS); operations phase; automated data systems; *SP500-94*; 1982 October. 68-75.

computer programs; fire growth; fire models; heat flux; mathematical models; walls; aircraft compartments; aircraft fires; ceilings; compartment fires; *NBS-GCR-82-404*.

computer reports; grant data; residential buildings; solar data base; solar energy system; solar hot water, space heating and cooling; automatic data processing; *NBSIR 81-2376*.

computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; standards; communications; *FIPS PUB 93*.

computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cassettes; magnetic tape recording; magnetic tape transports; standards; communications; *FIPS PUB 91*.

computers; energy; instrumentation; particle size; pigment; *21013*.

computers; Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); channel level power control interface; computer peripherals; *FIPS PUB 61-1*.

computer security; A-123; data processing; computer crime; *SP500-95*; 1982 October. 89-94.

computer security; contingency planning; emergency response; Federal Information Processing Standards Publication; recovery actions; ADP security; backup operations; *SP500-85*.

computer simulation; Couette flow; Lennard-Jones fluid; nonequilibrium molecular dynamics; nonlinear phenomena; phase changes; stability criteria; thermodynamics of the steady state; *20959*.

computer simulation; emergency egress; fire research; human performance; modeling; pedestrian movement; regulatory process; simulation of human behavior; building codes; building fires; computer-aided design; *20911*.

computer simulation; external aerodynamics; fluid dynamics; mathematical modeling; numerical methods; unsteady flow; vortex shedding; *21044*.

computer simulation; fluid structure; nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; radial distribution function; shear; soft sphere fluid; viscosity; *21237*.

computer simulation; infiltration; natural ventilation; building energy analysis; *21123*.

computer simulation; laser beam profile; mode-matching analysis; spatial filter; target designators; *TN1057*.

computer simulation; life cycle costs; maintenance, track; Simulation Cost Model; track maintenance planning; track standards; *SP640*; 1982 October. 199-215.

computer simulation; local area network; computer performance modeling; *SP500-95*; 1982 October. 107.

computer simulation; mathematical modeling; pulse circuits; *SP628*; 1982 June. 133-149.

computer simulation models; Federal Life-Cycle Cost Rules; life-cycle cost analysis; net savings; solar energy computer program; solar energy economics; solar energy systems; *NBSIR 81-2379*.

computer software; documentation standards; machine-readable data files (MRDF); bibliographic control; bibliographic standards; *SP500-94*; 1982 October. 183-188.

computer software; FORTRAN; gage blocks; measurement assurance; statistical control; statistical tests; *TN1168*.

computer standards; DBMS; database management; database standards; Data Base System Study Group; query language; relation; relational model; Relational Task Group; American National Standards Institute; *NBS-GCR-82-379*.

computer tele/conferencing; integrating computer conferencing; management information systems; *SP500-95*; 1982 October. 427-431.

computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems; artificial intelligence; automation; computational; computer perception; *NBSIR 82-2582*.

computing environment; large-scale scientific computing; parallel processing; scientific workload; vector processing; Amdahl's Law; benchmarking; *SP500-95*; 1982 October. 121-126.

concave; convex; inequality; majorization; median; statistical methods; *J. Res. 87(1)*: 71-74; 1982 January-February.

concentration; correlation function; density; rare gas mixtures; spectral behavior; absorption spectrum; atomic masses; collision-induced absorption; *21007*.

concentration coefficient of diffusivity; density; diffusion coefficient; drawing stress; low density polyethylene; plastic deformation; sorbate concentration; sorption; weight gain; *20876*.

concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; *SP489, Supplement 1*.

concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; *21250*.

concepts; Information Resource Management; Information Systems Management; management-tool; methodologies; strategies; techniques; *SP500-95*; 1982 October. 5-9.

conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; *TN1150*.



concerted reaction; cyclobutane; ozonation; thiolane; 20958.

concrete; concrete strength; construction; cooling tower; failure; hyperbolic shell; shell; collapse; *BSS148*.

concrete; concrete strength; construction; failure; flat plate; shear; strength; building; collapse; *BSS145*.

concrete; construction; failure investigation; falsework; field load tests; formwork; post-tensioning; structural analysis; bridge; collapse; *NBSIR 82-2593*.

concrete; crack propagation; failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; large scale models; mathematical model; pullout test; stress contours; *NBSIR 82-2484*.

concrete; evaluation; inplace testing; inspection; nondestructive testing; quality assurance; building materials; *J. Res. 87(5): 407-438*; 1982 September-October.

concrete; laboratory accreditation; NVLAP; testing; commercial laboratories; *SP632*; 1982 March. 54-56.

concrete mortar; elongation; low temperature; maximum strength; mechanical properties; yield strength; Young's modulus; compressive strength; *NBSIR 82-1658*.

concretes; creep tests; fire tests; high temperature tests; aggregates; *NBS-GCR-82-407*.

concretes; regression analysis; safety; shear properties; splitting tensile strength; statistical analysis; age-strength relation; building codes; compressive strength; 21150.

concrete strength; construction; cooling tower; failure; hyperbolic shell; shell; collapse; concrete; *BSS148*.

concrete strength; construction; failure; flat plate; shear; strength; building; collapse; concrete; *BSS145*.

condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; *SP640*; 1982 October. 235-254.

condition monitoring; roller bearings; thermal analysis; bearing failure; bearing reliability; *SP640*; 1982 October. 295-325.

condition monitoring module; microcomputer; administrative system for maintenance; automatic condition monitoring; *SP640*; 1982 October. 71-85.

conductance; pH; precipitation; rain; reference materials; trace elements; acidity; acid rain; chemical analysis; *NBSIR 82-2581*.

conduction states; donors; effective mass; energy dispersion; impurities; silicon; valence states; Yukawa potential; bandgap narrowing; Bargmann potential; 20855.

conductivity; croconates; crystallographic; electrical; electrochemical; mechanism;  $\pi$ -acceptors; semiconduction; *J. Res. 87(3): 257-260*; 1982 May-June.

conductivity; electrical; impedance; polyacetylene; transport; 20853.

conductivity; electrical property; metals; polymers; resistance; resistivity; review; alloys; *TN1053*.

conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; *NBSIR 81-2356*.

conductivity; high temperature; impedance; resistivity; coal slag; 21182.

connection; construction; failure; steel; walkway; building; collapse; *BSS143*.

consensus values; design of experiments; pooling of variance; weighted average; weighted least squares regression; ANOVA (within-between); components of variance; *J. Res. 87(5): 377-385*; 1982 September-October.

conservation; riparian doctrine; water law; *SP624*; 1982 June. 17-26.

conservation laws; Environmental Policy Institute; water conservation; *SP624*; 1982 June. 61-66.

conservation management; federal water policy; *SP624*; 1982 June. 409-412.

conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; *SP489, Supplement 1*.

conservation policy; water conservation; American Water Works Association (AWWA); *SP624*; 1982 June. 207-209.

conservation program; water conservation education program; *SP624*; 1982 June. 443-447.

conservation programs; residential water conservation; water-saving plumbing devices; appliances; *SP624*; 1982 June. 193-196.

constant loading; high precision; load cell; mass comparator; substitution weighing; weighing; *J. Res. 87(1): 47-48*; 1982 January-February.

constraint; database; database management system; data correctness; integrity; networks; remote access of data; semantic integrity; 21124.

construction; cooling tower; failure; hyperbolic shell; shell; collapse; concrete; concrete strength; *BSS148*.

construction; Department of Defense; Tri-Services Committee; building materials; building technology; 21039.

construction; failure; flat plate; shear; strength; building; collapse; concrete; concrete strength; *BSS145*.

construction; failure; steel; walkway; building; collapse; connection; *BSS143*.

construction; failure investigation; falsework; field load tests; formwork; post-tensioning; structural analysis; bridge; collapse; concrete; *NBSIR 82-2593*.

construction materials; health risk; polarized light microscopy; asbestos; bulk standards; *SP619*; 1982 March. 34-43.

consumer education; drought-tolerant plant; water conservation; *SP624*; 1982 June. 27-36.

consumer education; energy conservation; feedback; incentives; metering; rate structures; water conservation; *NBSIR 80-2119*.

consumer interest; consumer rights; laboratory accreditation; *SP632*; 1982 March. 65-67.

consumer rights; laboratory accreditation; consumer interest; *SP632*; 1982 March. 65-67.

contact derailment sensor; g-sensing derailment detector; local derailment; nitinol sensor; on-board failure detection system; overheated bearings; thermal switch sensor; train line; *SP621*; 1982 October. 49-68.

contacts; gallium arsenide; potential profiling; spreading resistance; *NBSIR 81-2403*.

containers; corrosion; corrosion data; geothermal brines; metals; nuclear waste; underground; alloys; *NBSIR 81-2409*.

contaminant control; standards; tobacco smoke; ventilation; air pollution modeling; air quality; 20848.

contamination; dew point; hermetic packages; moisture; packaging; water vapor; *SP400-72*; 1982 April. 76-78.

contamination; filter loading; aerosolized fibers; airborne asbestos; analytical methods; *SP619*; 1982 March. 77-84.

contamination control; leachates; leach testing; nuclear waste; trace elements. nuclear waste; trace elements; chemical blank; 21372.

contamination control; sample handling; sample storage; sampling; trace element analysis; analytical blank; 21373.

contention; data; digital; Ethernet; local; microprocessor; network; serial; broadcast; coaxial; communication; 20839.

contingency planning; disaster recovery; empty shell; reciprocal aid; recovery center; redundant facilities; shared contingency facility; backup operations; *SP500-95*; 1982 October. 439-441.

contingency planning; emergency response; Federal Information Processing Standards Publication; recovery actions; ADP security; backup operations; computer security; *SP500-85*.

continuum; double electron; excitation; sodium; 2s; 21331.

continuum; irradiance; plasma; rare-earth; absolute; calibration; 21016.

continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; 21175.

continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; 20836.

control; daylight; energy balance; natural ventilation; psychological needs; view out; window; window management; 21043.

control; heat exchanger; modeling; monitoring; research; steam; thermal response; valve; air conditioning; building systems; computer; 21048.

control; modeling; office building; thermal response; ventilation; air conditioning; air distribution; building systems; computer; 21047.

control cable; control head; D-subminiature connector; interchangeability; law enforcement; microphone cable; mobile transceiver; performance standard; cable assembly; cable connector; 20904.

control head; D-subminiature connector; interchangeability; law enforcement; microphone cable; mobile transceiver; performance standard; cable assembly; cable connector; control cable; 20904.



controlled installation; leak detection; preventive maintenance; rental apartment complexes; waste flow; water conservation; watersaving devices; *SP624*; 1982 June. 169-171.

controller; IEEE 488 Bus; total power radiometer; automated noise measurement system; coaxial noise sources; *NBSIR 81-1656*.

control water flow; flow control devices; multi-housing properties; plumbing fixtures; water consumption; water-saving plumbing; *SP624*; 1982 June. 47-51.

convection; finite difference approximation; heat transfer; natural convection; nonlinear convection; numerical integration; transient fluid motion; transient heat transfer; compressible fluid motion; *NBSIR 82-1660*.

convection; foam; gas conduction; guarded-hot-plate; insulation; low temperature; radiation; solid conduction; thermal conductivity; *NBSIR 82-1664*.

convection; gallium-tin alloys; levitation calorimetry; segregation; specific heat; surface tension; thermophysical properties; tungsten; Auger spectroscopy; *NBSIR 82-2560*.

convection; heat defect; radiation chemistry; thermistor; water; absorbed dose; calorimeter; *J. Res. 87(3)*: 211-235; 1982 May-June.

conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; portability; program inventory; RFP; statement of work; acceptance tests; *SP500-90*.

conversion factors; dose equivalent; field measurement; Health Physics Society; neutrons; photons; standard; testing program; *20813*.

conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; portability; program inventory; RFP; statement of work; acceptance tests; conversion contracting; *SP500-90*.

converter; distortion; microcomputer; rms value; sampling; signal period; algorithm; *TN1159*.

converters; electromagnetics; encoders; pulse; standards; waveform generation; waveform measurements; waveform recorder; *SP634*.

converter testing; dynamic testing; high resolution; settling time; step response; analog-to-digital converters; code transition levels; *20908*.

convex; inequality; majorization; median; statistical methods; concave; *J. Res. 87(1)*: 71-74; 1982 January-February.

co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; concept relations; *21250*.

cooling; heating; heating seasonal performance; heating seasonal performance factor; heat pumps; test method; water source heat pumps; central heating equipment; *NBSIR 81-2287*.

cooling; heating; hot water; performance criteria; solar energy; standards; building; *BSS147*.

cooling; heating; hot water; performance criteria; solar energy; standards; buildings; *21082*.

cooling rate; crystalline; dendrites; interfaces; microcrystalline; nucleation; recalescence; solidification; undercooling; amorphous; *21090*.

cooling rate; dew point; leakage current; capacitance; *SP400-72*; 1982 April. 98-104.

cooling tower; failure; hyperbolic shell; shell; collapse; concrete; concrete strength; construction; *BSS148*.

coordinate time; frequency standards; international atomic time; relativity; satellite clocks; SI second; synchronization; syntonization; time scales; *21188*.

coordinate transformation; custody transfer; energy; liquid natural gas; *21324*.

copolymer; electrical properties; piezoelectricity; poling; pyroelectricity; tetrafluoroethylene; vinylidene fluoride; charge transport; *20840*.

copolymer; phase transition in polymers; polymer crystals; block copolymers; chain folding in polymers; *21066*.

copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; *20955*.

copolymers; crystal; hexafluoropropylene; polytetrafluoroethylene; tetrafluoroethylene; x-ray diffraction; *21164*.

copolymers; kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; chromatography; *NBSIR 81-2424*.

copper; critical current; electrical property; magnetic field; measurement; niobium; superconductor; tin; titanium; *21218*.

copper; gold; nickel; photoelectrons; surface analysis; Auger electrons; *20986*.

copper; gold; silver; single crystal; thin films; aluminium; clusters; *21012*.

copper complex; corrosion inhibitor; crystal structure; single crystal x-ray diffraction; tridentate ligand; azometallic cycle; benzotriazoleanion; *21297*.

copper single crystal; image contrast; indentation hardening; plastic deformation; x-ray topography; *21353*.

copyright law; inflation; interlibrary lending; journal prices; library photocopying; publishers; book prices; *21380*.

core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; *21175*.

core-holes; mixed-valence; photoionization; resonance; ytterbium; Auger; *21105*.

Cornu-spirals; curvature; curve fitting; Fresnel-integrals; interpolation; splines; approximation; clothoids; computer-aided design; *J. Res. 87(4)*: 317-346; 1982 July-August.

corona discharge; corona pulse characteristics; decomposition products; gas chromatograph-mass spectrometer;  $H_2O$ ; sulfur hexafluoride; *21247*.

corona discharge; HEPA filters; ion counters; ion density; ions; net space charge; *NBSIR 82-2486*.

corona discharges; electron avalanches; gas chromatograph; mass spectrometer;  $SF_6$ ; streamer pulses; sulfurhexafluoride; water vapor; *21379*.

corona pulse characteristics; decomposition products; gas chromatograph-mass spectrometer;  $H_2O$ ; sulfur hexafluoride; corona discharge; *21247*.

corporate; Corporate Standard Quality System; individual; laboratory; accreditation procedures; *SP632*; 1982 March. 52-53.

Corporate Standard Quality System; individual; laboratory; accreditation procedures; corporate; *SP632*; 1982 March. 52-53.

correlation; critical evaluation; electrolyte theories; models; osmotic coefficient; polyvalent electrolytes; thermodynamics properties; activity coefficient; *20935*.

correlation; dispersancy; engine sequence tests; hot tube; laboratory bench tests; oxidation; solubilization; automotive crankcase oils; bench test procedures; catalysts; *21279*.

correlation; energy transfer; fire tests; flame spread; ignition; mass loss; test methods; calorimeters; *NBSIR 82-2536*.

correlation; fire tests; full-scale; smoke; smoke density chamber; optical density; test methods; visibility; *NBSIR 82-2508*.

correlation; microcircuits; MIL-STD-8833; moisture measurement; moisture standards; analytical laboratories; *SP400-72*; 1982 April. 126-127.

correlation coefficient; outlier; process validation wafer; statistical analysis; two-dimensional arrays; wafer map; computer program; *NBSIR 82-2492*.

correlation function; density; rare gas mixtures; spectral behavior; absorption spectrum; atomic masses; collision-induced absorption; concentration; *21007*.

correlations; corridor tests; fire growth; fire tests; flammability; flashover; interior finishes; room fires; compartment fires; *NBSIR 82-2525*.

corresponding states; critical point universality; liquefaction of helium; mechanical equivalence; mixtures; molecular potential; quantum parameter; *20899*.

corresponding states; Enskog model; equation of state; hard spheres; propane; viscosity; *21225*.

corridors; flame spread; polymers; room fires; thermal degradation; ceilings; charring; compartment fires; *NBS-GCR-82-377*.

corridor tests; fire growth; fire tests; flammability; flashover; interior finishes; room fires; compartment fires; correlations; *NBSIR 82-2525*.

corrosion; corrosion data; geothermal brines; metals; nuclear waste; underground; alloys; containers; *NBSIR 81-2409*.

corrosion; crevice corrosion; galvanic corrosion; implant materials; implants; passivity; pitting; *20881*.

corrosion; dew point; failure modes; hybrid manufacturing; moisture sources; adsorption; *SP400-72*; 1982 April. 117-125.

corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life



adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; *SP640*; 1982 October. 257-274.

corrosion; electrochemistry; frequency analysis; rectification; alternating voltage; charge-transfer; *20886*.

corrosion; electrochemistry; passivity; repassivation; surface modification; breakdown of passivity; *20928*.

corrosion; elevated temperature; heat transfer liquid degradation kinetics; simulated service test solar collector; *NBSIR 81-2339*.

corrosion; erosion; materials properties; mechanical properties; physical properties; refractories; alloys; coal conversion; coal gasification; *SP642*.

corrosion; failure prevention; human performance; material and material processing; mechanical and structural failure; operational environment; preventive maintenance; wear; *SP640*; 1982 October. 2-16.

corrosion; fatigue; microstructures; titanium; alloys; anodic polarization; *21174*.

corrosion; friction reduction; pipes; potable water; pressure reduction; residential buildings; sprinkler systems; water; *NBS-GCR-82-399*.

corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; *TN1150*.

corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground; alloys; *NBSIR 82-2509*.

corrosion control; erosion; flame spray process; plasma coatings; thermal deposition systems; thermospray process; wear; aluminum non-skid coating; *SP640*; 1982 October. 194-196.

corrosion damage; equipment design failures; marine environmental factors; moisture intrusion in avionic equipment; avionic component design; avionic corrosion damage; *SP640*; 1982 October. 379-399.

corrosion data; geothermal brines; metals; nuclear waste; underground; alloys; containers; corrosion; *NBSIR 81-2409*.

corrosion detection; cost savings; NDE; neutron radiography; preventive maintenance; composite inspection; *SP640*; 1982 October. 417-453.

corrosion inhibitor; crystal structure; single crystal x-ray diffraction; tridentate ligand; azometallocycle; benzotriazoleanion; copper complex; *21297*.

corrosion of an IC; IC surface; localized corrosion; surface model; *SP400-72*; 1982 April. 129-148.

corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; *21326*.

corrosivity monitoring device; exposure tests; marine environments; salt fog; alternate immersion; *SP640*; 1982 October. 476-494.

corrugated feed; near-field scanning application; offset, antenna; remote sensing of atmosphere; *21186*.

corundum; drop calorimetry; enthalpy; heat capacity; high temperature; standard reference material; synthetic sapphire; aluminum oxide; *J. Res. 87(2)*: 159-163; 1982 March-April.

cost accounting; costing; DP accounting; pricing; billing systems; chargeback systems; charging systems; *SP500-95*; 1982 October. 425.

cost benefit analysis; decision analysis; fire losses; fire safety; residential buildings; smoke detectors; sprinkler systems; *NBSIR 82-2551*.

cost-benefit analysis; economics; energy conservation; housing; insulation; space heating and cooling costs; space heating and cooling requirements; architecture; building design; *NBSIR 81-2380*.

cost-effective; data processing; infrared spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; *SP640*; 1982 October. 61-71.

cost effectiveness; maintenance effectiveness; preventive maintenance plan; programmed inspections; *SP640*; 1982 October. 86-112.

cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; *SP631*.

costing; DP accounting; pricing; billing systems; chargeback systems; charging systems; cost accounting; *SP500-95*; 1982 October. 425.

cost parameters; database management; data management evaluation; DBMS; decision model; preference parameters; requirements; *NBS-GCR-82-373*.

cost parameters; DBMS; database management; data management; data management evaluation; decision model; preference parameters; requirements; *NBS-GCR-82-374*.

costs; water conservation; water-related expenditures; benefits; *SP624*; 1982 June. 259-266.

cost savings; economic analysis; photomask linewidth measurements; semiconductors; accurate measurements; benefit-cost analysis; *NBSIR 82-2458*.

cost savings; NDE; neutron radiography; preventive maintenance; composite inspection; corrosion detection; *SP640*; 1982 October. 417-453.

costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization; residential energy consumption; weatherization; Community Action Agencies; Community Services Administration; *BSS144*.

costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization; Community Action Agencies; Community Services Administration; *NBSIR 82-2539*.

costs of weatherization; energy conservation; energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; *TN1156*.

Couette flow; Lennard-Jones fluid; nonequilibrium molecular dynamics; nonlinear phenomena; phase changes; stability criteria; thermodynamics of the steady state; computer simulation; *20959*.

Coulomb sum rule; electron scattering; Fermi gas model; nuclear response function; nuclei; nucleons; quasi-free; charge magnetization; *21400*.

coulometer; electrochemical equivalent; Faraday constant; fundamental constants; silver; silver coulometer; atomic weight; atomic weight of silver; *J. Res. 87(1)*: 21-22; 1982 January-February.

counter; timer; watt-hour meter; *21266*.

count rate effects; dead time; errors; pulse pileup; accuracy; activation analysis; *21249*.

coupled growth; eutectic solidification; metallic glasses; palladium-copper-silicon alloys; rapid solidification; amorphous alloys; *21190*.

coupled nonlinear oscillators; nonlinear analysis; perturbation theory; *21117*.

coverage analysis; dynamic analysis; performance monitoring; program analysis; program instrumentation; software tools; *SP500-95*; 1982 October. 195-202.

cover plate materials; durability; natural weathering; solar collectors; solar energy; solar energy transmittance; tensile properties; weathering of cover plates; artificial weathering; *TN1170*.

CO<sub>2</sub> laser; decane; ignition; absorption; *21304*.

CO<sub>2</sub> laser; decomposition; ignition; polymethacrylate; radiation; surface temperature; wood; absorption; *20792*.

CO<sub>2</sub> laser; elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; free-free transitions; Nd laser; photon-assisted transitions; angular distributions; close-coupling approximation; *20787*.

CO<sub>2</sub> saturation spectra; diode laser spectra; heterodyne spectroscopy; isotope enrichment isotope separation; SiF<sub>4</sub> spectra; *21216*.

CPU utilization; queue drops; VM monitor; VM performance analysis; *SP500-95*; 1982 October. 321-329.

crack detection; fissure detection; fissures; vapor crack detection; ceramic crack detection; ceramic cracks; ceramic fissures; *SP400-72*; 1982 April. 201-211.

crack detection; inspection interval; rail flaw detection; *SP621*; 1982 October. 69-90.

crack growth; creep-fatigue; mechanical testing; multiaxial tests; stress-corrosion; computer controlled mechanical test; *21111*.

crack growth model; creep cavitation; diffusive crack growth; energy release rate; high temperature fracture; *J*-integral; Si-Al-O-N; singular integral equation; *20931*.

crack growth of ceramics; four-point bend test; fracture test; initial value problem; load-displacement characteristics; power-law crack growth; ceramic fracture test; *NBSIR 82-2504*.

crack initiation; crack opening displacement; ductile fracture; leak vs.



break; part-through crack; pipeline fracture; plastic necking instability; progressive crack growth; *SP621*; 1982 October. 153-164.

crack opening displacement; ductile fracture; leak vs. break; part-through crack; pipeline fracture; plastic necking instability; progressive crack growth; crack initiation; *SP621*; 1982 October. 153-164.

crack opening displacement; finite element analysis; fitness-for-service; fracture mechanics; J-integral; *21194*.

crack propagation; failure; fatigue; fracture; fracture surface; fracture toughness; analysis; bridges; *SP621*; 1982 October. 95-109.

crack propagation; failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; large scale models; mathematical model; pullout test; stress contours; concrete; *NBSIR 82-2484*.

cracks; defects; failure; fracture mechanics; girth welds; pipeline; plasticity; strength; stress; toughness; collapse; *21169*.

cracks; finite element method; nondestructive evaluation; scattering; ultrasonic waves; variational method; acoustic waves; *21229*.

cracks; fracture; glass; static fatigue; strength; subcritical crack growth; *NBSIR 82-2524*.

creep; fatigue; morphology; polyethylene; stress-crack resistance; stress-relaxation; ultra high molecular weight; *NBSIR 82-2493*.

creep cavitation; diffusive crack growth; energy release rate; high temperature fracture; J-integral; Si-Al-O-N; singular integral equation; crack growth model; *20931*.

creep-fatigue; mechanical testing; multiaxial tests; stress-corrosion; computer controlled mechanical test; crack growth; *21111*.

creep tests; fire tests; high temperature tests; aggregates; concretes; *NBS-GCR-82-407*.

creosote; fire safety; fire tests; flues; heating equipment; stoves; wood; chimneys; *NBS-GCR-82-368*.

creosote; fire safety; flues; heating equipment; stoves; tar; temperature measurements; wood; chimneys; *NBS-GCR-81-365*.

crevice corrosion; electrochemical techniques; localized corrosion; localized corrosion mechanism; pitting; accelerated testing; *NBSIR 82-2477*.

crevice corrosion; galvanic corrosion; implant materials; implants; passivity; pitting; corrosion; *20881*.

Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkyldioxy; carbene oxidation; *21254*.

Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkyldioxy; carbene oxidation; *21255*.

criteria; definitions; history; international trade; laboratory accreditation; need; *SP632*.

criteria; measurement methods; performance criteria; project summaries; technical bases; building research; building technology; codes; *SP446-6*.

critical current; critical temperature; electrical property; low-temperature; standard; superconductor; *21014*.

critical current; electrical property; magnetic field; measurement; niobium; superconductor; tin; titanium; copper; *21218*.

critical evaluation; electrolyte; excess Gibbs energy; osmotic coefficient; solutions; thermodynamic properties; activity coefficient; *20936*.

critical evaluation; electrolyte theories; models; osmotic coefficient; polyvalent electrolytes; thermodynamics properties; activity coefficient; correlation; *20935*.

critical fields; ferromagnetism; rare earths; scandium alloys; spin glass; antiferromagnetism; *21129*.

critically evaluated data; crystallographic data; experimental melting curves; high pressure; high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; *JPCRD 11(4)*: 1005-1064; 1982.

critically evaluated data; density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties; argon; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; *JPCRD 11(1)*: 83-99; 1982.

critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables; *JPCRD 11(3)*: 695-940; 1982.

critical phenomena in space; critical point; dielectric constant; gravity effects; light scattering; *20875*.

critical point; dielectric constant; gravity effects; light scattering; critical phenomena in space; *20875*.

critical point universality; liquefaction of helium; mechanical equivalence; mixtures; molecular potential; quantum parameter; corresponding states; *20899*.

critical tables; data evaluation; physical properties; reference data; chemical properties; *21389*.

critical temperature; electrical property; low-temperature; standard; superconductor; critical current; *21014*.

croconates; crystallographic; electrical; electrochemical; mechanism;  $\pi$ -acceptors; semiconduction; conductivity; *J. Res. 87(3)*: 257-260; 1982 May-June.

croconates; dicyanomethylene; electrochemical; electron-transfer; mechanism; oxidation; reversible; salts; *21103*.

cross-bridge structure; linewidth; microelectronic test structure; process control; sheet resistance; test structure; *NBSIR 82-2548*.

cross-correlation; diffusion flames; entrainment; heat flux; radiation; turbulence; buoyancy; *NBSIR 82-2473*.

crossed beams; cross sections; electron impact excitation; lifetime; polarization; Zn<sup>+</sup>; *21072*.

crossed beams; electron impact; excitation-autoionization; Ga<sup>+</sup>; ionization; Zn<sup>+</sup>; *21071*.

crossed beams; electron-ion collisions; excitation; Ga II; resonance line; absolute cross section; *21317*.

cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; specific heat; thermosetting polymers; varnishes; adiabatic calorimetry; automated calorimetry; *21032*.

crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon; *20900*.

cross-section; description; passive; physical; property; sensor; solar test building; *NBS-GCR-82-398*.

cross section; electron-ion pairs; electron shells; molecules; photoionization; atoms; *21056*.

cross section; form factor; Rayleigh scattering; tabulation; water; x rays; coherent scattering; *JPCRD 11(4)*: 1091-1098; 1982.

cross sections; data base; electron; photon; transport; bremsstrahlung; *21384*.

cross sections; elastic scattering; electron-impact ionization; electrons; photons; stopping power; transport; bremsstrahlung; *NBSIR 82-2572*.

cross sections; electron impact; excitation-autoionization; ionization; Mg<sup>+</sup>; Na iso-sequence; Si<sup>3+</sup>; Al<sup>2+</sup>; crossed beams; *21073*.

cross sections; electron impact excitation; lifetime; polarization; Zn<sup>+</sup>; crossed beams; *21072*.

cryocooler; cryogenics; low temperature; refrigerator; Stirling cycle; superconducting devices; *TN1049*.

cryogenic mechanical properties; fracture (materials); fracture toughness; J-integral; low-temperature tests; stainless steels; computer-aided mechanical tests; *20864*.

cryogenics; low temperature; refrigerator; Stirling cycle; superconducting devices; cryocooler; *TN1049*.

crystal; crystallinity; density; enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene; atactic; *JPCRD 11(2)*: 313-325; 1982.

crystal; hexafluoropropylene; polytetrafluoroethylene; tetrafluoroethylene; x-ray diffraction; copolymers; *21164*.

crystal-amorphous interface; fold surface; loops; polymer; semicrystalline polymer; tie molecules; amorphous phase; *21159*.

crystal data; diffraction; Hanawalt search procedure; powder diffraction file; x ray; *21271*.

crystal diffraction; gamma-ray standards; precision measurement; x-ray interferometry; x rays; *21086*.

crystal fields; ferromagnetism; manganese compounds; neutron diffraction; profile refinement; rare earths; *20944*.

crystal focusing; laboratory EXAFS; *21008*.

crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; *21392*.

crystal growth; encapsulants; failure mechanisms; nucleating agent; phase change storage; service life prediction; *NBSIR 81-2422*.



crystalline; dendrites; interfaces; microcrystalline; nucleation; recalescence; solidification; undercooling; amorphous; cooling rate; 21090.

crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion; chain conformation; 21395.

crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; 21392.

crystallinity; density; enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene; atactic; crystal; *JPCRD 11(2)*: 313-325; 1982.

crystallization; fraction; friction coefficient; growth rate; polyethylene; régime I; régime II; reptation; 21158.

crystallization of polymers; lamellae; chain folding; 21280.

crystallographic; electrical; electrochemical; mechanism;  $\pi$ -acceptors; semiconductor; conductivity; croconates; *J. Res. 87(3)*: 257-260; 1982 May-June.

crystallographic data; experimental melting curves; high pressure; high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; critically evaluated data; *JPCRD 11(4)*: 1005-1064; 1982.

crystallography; data analysis; determinative ratios; FORTRAN program; metric symmetry; reduced cell; 21269.

crystal spectroscopy; electrons; excitation; measurement; x-ray emission lines; x-ray photoelectron spectra; 21330.

crystal structure; densities; lattice constants; powder patterns; reference intensities; standard; x-ray diffraction; *Monogr. 25, Section 19*.

crystal structure; diffraction; isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation; activation analysis; *TN1160*.

crystal structure; dimer; fungal pigment; metabolite of pathogenic fungi; single crystal x-ray diffraction; xanthomegnin; absolute configuration; 21313.

crystal structure; hydrated phosphate; strontium phosphate; struvite-type structure; 21180.

crystal structure; hydration of XO<sub>4</sub> ion; magnesium arsenate hydrate; magnesium phosphate hydrate; struvite analogue; water-rich hydrates; 20873.

crystal structure; hydrogen; phase diagram; properties; solid; 20979.

crystal structure; inner salt; iodonium compound; ionic bonding; reaction intermediate; x-ray diffraction; 21268.

crystal structure; molecular structure; USP reference standard; x-ray diffraction; analgesic; anticonvulsant; azepine ring; carbamazepine; 21298.

crystal structure; single crystal x-ray diffraction; tridentate ligand; azometalloycycle; benzotriazoleanion; copper complex; corrosion inhibitor; 21297.

crystal structures; hydroxyapatite; octacalcium phosphate; sodium urate; biominerals; calcium carbonates; calcium oxalates; calcium phosphates; calcium pyrophosphate; 21110.

Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; 21205.

Cs; frequency standards; Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; 21217.

Cs IX; I VII; La XI; wavelengths; Xe VIII; Ba X; 20815.

Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion; chain conformation; crystalline transformation; 21395.

Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; 21392.

current density measurements; high efficiency particulate air filter; high voltage dc transmission lines; ion counter; ion density; net space charge density; *NBSIR 82-2527*.

current measurement; current monitor; current transformer; *SP628*; 1982 June. 194-203.

current measurement; current viewing resistors; pulse current; *SP628*; 1982 June. 217-232.

current measurement; electrical measurements; electromagnetic pulse; fusion; nuclear effects simulation; particle beam technology; pulse power; transients; voltage measurements; *SP628*.

current measurements; current viewing resistors; high di/dt particle beam accelerator; Rogowski coils; cavity current monitors; *SP628*; 1982 June. 266.

current measurements; gamma ray diagnostic technique; *SP628*; 1982 June. 267-276.

current measurements; pulse power system; signal transmission; system fault isolation; thyratrons; *SP628*; 1982 June. 248-255.

current monitor; current transformer; current measurement; *SP628*; 1982 June. 194-203.

current monitors; current probe; current pulses; pulse generators; Rogowski coils; *SP628*; 1982 June. 289-299.

current probe; current pulses; pulse generators; Rogowski coils; current monitors; *SP628*; 1982 June. 289-299.

current pulses; pulse generators; Rogowski coils; current monitors; current probe; *SP628*; 1982 June. 289-299.

current sensors; fluxmeters; pulsed current measurements; Rogowski coils; *SP628*; 1982 June. 175-193.

current transformer; current measurement; current monitor; *SP628*; 1982 June. 194-203.

current transformer; wide-band transformer; *SP628*; 1982 June. 233-243.

current transformers; precision shunts; pulsed currents; Zero Gradient Synchrotron; *SP628*; 1982 June. 204-216.

current viewing resistors; high di/dt particle beam accelerator; Rogowski coils; cavity current monitors; current measurements; *SP628*; 1982 June. 266.

current viewing resistors; pulse current; current measurement; *SP628*; 1982 June. 217-232.

curvature; curve fitting; Fresnel-integrals; interpolation; splines; approximation; clothoids; computer-aided design; Cornu-spirals; *J. Res. 87(4)*: 317-346; 1982 July-August.

curve fitting; Fresnel-integrals; interpolation; splines; approximation; clothoids; computer-aided design; Cornu-spirals; curvature; *J. Res. 87(4)*: 317-346; 1982 July-August.

curve-fitting; statistics; uncertainty limits; calibration; 20800.

custody transfer; density measurement; density reference standard; liquefied natural gas; computational methods; computer programs; 20946.

custody transfer; energy; liquid natural gas; coordinate transformation; 21324.

custom; integrated circuits; multifunction; parametric tester; reliability; standard; test chip; test structure; 20835.

cyclic loading; dynamic test; laboratory test; sand; shear test; simple shear test; size effects; 20857.

cyclic loading; field testing; flood forces; foundations; load capacity; mobile homes; soil anchors; soil mechanics; stiffness; wind forces; anchors; *BSS142*.

cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; residential furnaces; room temperature; thermal response factors; thermostat control; burner on-time; 20903.

cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; *BSS138*.

cyclic sulfide; ozone; vapor phase reaction; carbocyclic compound; *U.S. Patent 4,327,233*.

cyclobutane; ozonation; thiolane; concerted reaction; 20958.

cyclohexane; evaluation procedures; excess enthalpy; heat of mixing; benzene; *JPCRD 11(4)*: 1129-1151; 1982.

cyclohexane; evaluation procedures; excess Gibbs function; vapor-liquid equilibrium; activity coefficients; benzene; *JPCRD 11(4)*: 1099-1127; 1982.

cyclohexane; evaluation procedures; excess volume; volume change of mixing; benzene; *JPCRD 11(4)*: 1153-1171; 1982.

cyclopentane; photofragmentation; photoionization; quantum yields; radiation chemistry; vacuum ultraviolet; charge recombination; 21243.

cytochrome c; enzymatic digestion; high-performance liquid chromatography; peptides; amino acid analysis; anion-exchange; 21293.

C<sub>3</sub>K; inelastic neutron scattering; intercalated systems; lattice dynamics; phonons; two-dimensional systems; 20949.

c<sup>4</sup>S<sub>u</sub> limit; electrons; experimental; inelastic scattering; O<sub>2</sub>; Rydberg series; angular distributions; 21077.



# D

dam; lock; queue; simulation; waiting time; capacity; *NBSIR 81-2411*.  
 damage; fatigue; guys; mechanical testing; nondestructive testing; pultrusions; standards; composite materials; *21195*.  
 Damkohler number; flame spread; gas phase; heat transfer; laminar flame; Laser Doppler Velocimeter; opposed flow; solid fuel; *NBS-GCR-82-388*.  
 damped dispersion; energy curve; polarizabilities; Van der Waals; *20788*.  
 damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; *BSS138*.  
 data; digital; Ethernet; local; microprocessor; network; serial; broadcast; coaxial; communication; contention; *20839*.  
 data abstractions; implementation; PL/I; specifications; validation; assertions; *20943*.  
 data acquisition system; field data acquisition; field instrumentation; field performance of heat pumps; heat pumps; heat pump test methods; microcomputer; analog signal conditioning; *NBSIR 81-2285*.  
 data analysis; determinative ratios; FORTRAN program; metric symmetry; reduced cell; crystallography; *21269*.  
 database; database design; data dictionary system; data management; DBMS; information resource management; *SP500-92*.  
 database; database function; database management system; data model; schema; standards; system architecture; system components; *SP500-86*.  
 database; database management system; data correctness; integrity; networks; remote access of data; semantic integrity; constraint; *21124*.  
 database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; software; computer program; *NBS-GCR-82-386*.  
 database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; computer program; *NBS-GCR-82-387*.  
 database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; software; computer program; *NBS-GCR-82-384*.  
 database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; computer program; *NBS-GCR-82-385*.  
 database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; computer program; *NBS-GCR-82-386*.  
 database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve; *21176*.  
 data base; directory look-up; information retrieval; interactive processing; random access; computer indexing; *TN1167*.  
 data base; electron; photon; transport; bremsstrahlung; cross sections; *21384*.  
 database; orthography; bibliographic citations; capitalization practices; *SP500-94*; 1982 October. 215-218.  
 data base; residential buildings; solar data base; solar energy systems; solar heating and cooling; automatic data processing; *NBSIR 81-2369*.  
 database analysis; accessibility; barrier-free design; building accessibility; *NBSIR 82-2567*.  
 database design; database design tools; database management; logical database design; logical database design tools; schema design; *NBS-GCR-82-389*.  
 database design; database management; database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; schema design; *NBS-GCR-82-390*.  
 database design; data dictionary system; data management; DBMS; information resource management; database; *SP500-92*.  
 database design tools; database management; logical database design; logical database design tools; schema design; database design; *NBS-GCR-82-389*.  
 database function; database management system; data model; schema; standards; system architecture; system components; database; *SP500-86*.  
 database management; database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; schema design; database design; *NBS-*

*GCR-82-390*.  
 database management; databases; database system features; database systems; operating system capabilities; operating systems; *NBS-GCR-82-393*.  
 database management; database standards; Data Base System Study Group; query language; relation; relational model; Relational Task Group; American National Standards Institute; computer standards; DBMS; *NBS-GCR-82-379*.  
 database management; data management; data management evaluation; decision model; preference parameters; requirements; cost parameters; DBMS; *NBS-GCR-82-374*.  
 database management; data management; data management evaluation; decision model; preference parameters; requirements; cost parameters; DBMS; *NBS-GCR-82-375*.  
 database management; data management evaluation; DBMS; decision model; preference parameters; requirements; cost parameters; *NBS-GCR-82-373*.  
 database management; DBMS; functional specification; mandatory requirements; optional requirements; procurement; relational; standards; *NBS-GCR-82-372*.  
 database management; logical database design; logical database design tools; schema design; database design; database design tools; *NBS-GCR-82-389*.  
 data base management; spatial economics; water conservation; water distribution systems; water supply simulation model; analytical mathematical modeling; *SP624*; 1982 June. 239-245.  
 database management system; data correctness; integrity; networks; remote access of data; semantic integrity; constraint; database; *21124*.  
 database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; computer program; database; *NBS-GCR-82-387*.  
 database management system; data dictionary system; data management; data standards; ERA model; information resource management; software; computer program; database; *NBS-GCR-82-384*.  
 database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; computer program; database; *NBS-GCR-82-385*.  
 database management system; data dictionary system; data management; data standards; ERA model; information resource management; software; computer program; database; *NBS-GCR-82-386*.  
 database management system; data model; schema; standards; system architecture; system components; database; database function; *SP500-86*.  
 database management system; DBMS; network data model; access control; CODASYL; *NBS-GCR-82-370*.  
 database management systems; data models; DBMS; DBMS architecture; standards; *NBS-GCR-81-340*.  
 database management systems; data models; DBMS simulation; positional set notation; set-theoretic; *21270*.  
 database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; schema design; database design; database management; *NBS-GCR-82-390*.  
 databases; database system features; database systems; operating system capabilities; operating systems; database management; *NBS-GCR-82-393*.  
 database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; schema design; database design; database management; database modeling; *NBS-GCR-82-390*.  
 database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; schema design; database design; database management; database modeling; *NBS-GCR-82-390*.  
 database standards; Data Base System Study Group; query language; relation; relational model; Relational Task Group; American National Standards Institute; computer standards; DBMS; database management; *NBS-GCR-82-379*.  
 database system features; database systems; operating system capabilities; operating systems; database management; databases; *NBS-GCR-82-393*.  
 database systems; operating system capabilities; operating systems; database management; databases; database system features; *NBS-*



Data Base System Study Group; query language; relation; relational model; Relational Task Group; American National Standards Institute; computer standards; DBMS; database management; database standards; *NBS-GCR-82-379*.

data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; *SP631*.

data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve; database; *21176*.

data compilation; dielectric properties; electrical properties; mechanical properties; thermal properties; thermodynamic properties; thermophysical properties; basalt; chemical characterization; *NBSIR 82-2587*.

data compilation; energy and environmental data; evaluated data; materials data; standard reference data; technical activities 1981; thermochemical and thermophysical data; *NBSIR 81-2442*.

data conversion; dynamic response; linearity; metrology support; phase angle calibration; signal sampling; stability; waveform synthesis; ac-dc difference; *21027*.

data correctness; integrity; networks; remote access of data; semantic integrity; constraint; database; database management system; *21124*.

data dictionary/directory; residential buildings; solar data energy system; solar heating and cooling; automatic data processing; *NBSIR 81-2357*.

data dictionary system; data management; data standards; ERA model; information resource management; software; computer program; database; database management system; *NBS-GCR-82-386*.

data dictionary system; data management; data standards; ERA model; information resource management; software; computer program; database; database management system; *NBS-GCR-82-384*.

data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; computer program; database; database management system; *NBS-GCR-82-385*.

data dictionary system; data management; data standards; information resource management; interactive language; language structure; software; computer program; database; database management system; *NBS-GCR-82-387*.

data dictionary system; data management; DBMS; information resource management; database; database design; *SP500-92*.

data documentation; machine-readable; text formatters; *SP500-94*; 1982 October. 203-208.

data element dictionary; guidelines; bibliographic data; *SP500-94*; 1982 October. 209-214.

data entry; Federal Information Processing Standard; graphic shapes; magnetic ink characters; MICR; MICR Read Optically; OCR; optical character recognition; character shapes; *FIPS PUB 32-1*.

data evaluation; gas phase; photo-absorption cross section; photochemistry; quantum yield; rate coefficient; air pollution; atmospheric chemistry; chemical kinetics; *JPCRD 11(2)*: 327-496; 1982.

data evaluation; physical properties; reference data; chemical properties; critical tables; *21389*.

data handbook; diagnostic radiology; general physics; medical physics; nonionizing radiation; nuclear medicine; radiation therapy; *H138*.

data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; standards; communications; computers; *FIPS PUB 93*.

data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cassettes; magnetic tape recording; magnetic tape transports; standards; communications; computers; *FIPS PUB 91*.

data management; data management evaluation; decision model; preference parameters; requirements; cost parameters; DBMS; database management; *NBS-GCR-82-374*.

data management; data management evaluation; decision model; preference parameters; requirements; cost parameters; DBMS; database management; *NBS-GCR-82-375*.

data management; data standards; ERA model; information resource management; software; computer program; database; database management system; data dictionary system; *NBS-GCR-82-386*.

data management; data standards; ERA model; information resource management; software; computer program; database; database management system; data dictionary system; *NBS-GCR-82-384*.

data management; data standards; information resource management; interactive language; language structure; software; computer program; database; database management system; data dictionary system; *NBS-GCR-82-385*.

data management; data standards; information resource management; interactive language; language structure; software; computer program; database; database management system; data dictionary system; *NBS-GCR-82-387*.

data management; DBMS; information resource management; database; database design; data dictionary system; *SP500-92*.

data management evaluation; DBMS; decision model; preference parameters; requirements; cost parameters; database management; *NBS-GCR-82-373*.

data management evaluation; decision model; preference parameters; requirements; cost parameters; DBMS; database management; data management; *NBS-GCR-82-374*.

data management evaluation; decision model; preference parameters; requirements; cost parameters; DBMS; database management; data management; *NBS-GCR-82-375*.

data model; schema; standards; system architecture; system components; database; database function; database management system; *SP500-86*.

data models; DBMS; DBMS architecture; standards; database management systems; *NBS-GCR-81-340*.

data models; DBMS simulation; positional set notation; set-theoretic; database management systems; *21270*.

data processing; computer crime; computer security; A-123; *SP500-95*; 1982 October. 89-94.

data processing; Information Resource Management; productivity; computer-based applications; *SP500-95*; 1982 October. 19-24.

data processing; infrared spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; cost-effective; *SP640*; 1982 October. 61-71.

data processing documentation; systems documentation; *SP500-94*; 1982 October. 247-255.

data reduction; Fourier analysis; piezoelectric polymers; polarization distribution; thermal pulse experiment; charge distribution; computer analysis; *21155*.

data reduction; sinewave; waveform digitizers; *SP634*; 1982 June. 23-25.

data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; units; *20888*.

data standards; ERA model; information resource management; software; computer program; database; database management system; data dictionary system; data management; *NBS-GCR-82-384*.

data standards; ERA model; information resource management; software; computer program; database; database management system; data dictionary system; data management; *NBS-GCR-82-386*.

data standards; information resource management; interactive language; language structure; software; computer program; database; database management system; data dictionary system; data management; *NBS-GCR-82-387*.

data standards; information resource management; interactive language; language structure; software; computer program; database; database management system; data dictionary system; data management; *NBS-GCR-82-385*.

data tuning; modeling; MVS; performance measurement data; software tuning; *SP500-95*; 1982 October. 313-320.

daylight; energy balance; natural ventilation; psychological needs; view out; window; window management; control; *21043*.

daylighting; glazing transmission; shading algorithms; solar access; solar radiation data; urban solar application; *NBSIR 82-2498*.

DBMS; database management; database standards; Data Base System Study Group; query language; relation; relational model; Relational Task Group; American National Standards Institute; computer standards; *NBS-GCR-82-379*.

DBMS; database management; data management; data management evaluation; decision model; preference parameters; requirements; cost parameters; *NBS-GCR-82-374*.



DBMS; database management; data management; data management evaluation; decision model; preference parameters; requirements; cost parameters; *NBS-GCR-82-375*.

DBMS; DBMS architecture; standards; database management systems; data models; *NBS-GCR-81-340*.

DBMS; decision model; preference parameters; requirements; cost parameters; database management; data management evaluation; *NBS-GCR-82-373*.

DBMS; functional specification; mandatory requirements; optional requirements; procurement; relational; standards; database management; *NBS-GCR-82-372*.

DBMS; information resource management; database; database design; data dictionary system; data management; *SP500-92*.

DBMS; network data model; access control; CODASYL; database management system; *NBS-GCR-82-370*.

DBMS architecture; standards; database management systems; data models; DBMS; *NBS-GCR-81-340*.

DBMS simulation; positional set notation; set-theoretic; database management systems; data models; *21270*.

dc-coupled probe; 2-ns risetime; 100-kV rating; *SP628*; 1982 June. 46-53.

dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; *NBSIR 82-2528*.

dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; *NBSIR 82-2501*.

dc fields; high voltage; incipient fault; insulation; SF<sub>6</sub>; space charge; transformer oil; cables; *NBSIR 82-2586*.

dc Josephson effect; Josephson junctions; superconductivity; supercurrent; tunneling; ac Josephson effect; *21316*.

dead time; errors; pulse pileup; accuracy; activation analysis; count rate effects; *21249*.

Debye-Waller factor; lattice dynamics; lithium; molecular dynamics; rubidium; anharmonic effects; *21096*.

decane; ignition; absorption; CO<sub>2</sub> laser; *21304*.

decarburation zones; implantation by mechanical inclusion; macromolecular clustering; molybdenum disulphide imbedment; carbide precipitation; *SP640*; 1982 October. 187-193.

decision analysis; fire investigations; firesetters; accelerants; arson; *21256*.

decision analysis; fire losses; fire safety; residential buildings; smoke detectors; sprinkler systems; cost benefit analysis; *NBSIR 82-2551*.

decision model; preference parameters; requirements; cost parameters; database management; data management evaluation; DBMS; *NBS-GCR-82-373*.

decision model; preference parameters; requirements; cost parameters; DBMS; database management; data management; data management evaluation; *NBS-GCR-82-375*.

decision model; preference parameters; requirements; cost parameters; DBMS; database management; data management; data management evaluation; *NBS-GCR-82-374*.

decoder; digital controlled; encoder; law enforcement standard; selective signaling; squelch systems; tone-coding; *20991*.

decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; *NSRDS-NBS72*.

decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; *20825*.

decomposition; ignition; polymethacrylate; radiation; surface temperature; wood; absorption; CO<sub>2</sub> laser; *20792*.

decomposition products; gas chromatograph-mass spectrometer; H<sub>2</sub>O; sulfur hexafluoride; corona discharge; corona pulse characteristics; *21247*.

deconvolution; digital sampling; fast Fourier transforms; sampling-rate drift; *SP634*; 1982 June. 47-53.

deep-level measurements; deep-level transient spectroscopy; defect characterization; lifetime; power-device grade silicon; transient capacitance techniques; *NBSIR 82-2552*.

deep-level measurements; defects; optical properties; silicon; sulfur; chemical interactions; *20842*.

deep level measurements; measurement methods; semiconductor materials characterization; semiconductors; thermally stimulated measurements; thermometry; *21144*.

deep-level transient spectroscopy; defect characterization; lifetime; power-device grade silicon; transient capacitance techniques; deep-level measurements; *NBSIR 82-2552*.

deep-level transient spectroscopy (DLTS); defect levels; dopant profiles; furnace anneal; ion implant; silicon; *NBS-GCR-81-364*.

deep space network; differential time transfer; frequency transfer; Global Positioning System; international time comparison; primary frequency standards; SI second; automatic time comparison; *21204*.

defect; dislocation; glide; inclusion; kink; tetragonal; Burgers vector; *20973*.

defect; isotope; metal hydride; neutron scattering; niobium hydride; tritide; vibration spectra; *20948*.

defect characterization; lifetime; power-device grade silicon; transient capacitance techniques; deep-level measurements; deep-level transient spectroscopy; *NBSIR 82-2552*.

defect detection; eddy current; failure prevention; ferro-magnetic alloys; inspection; metal distress; metal parts; NDE; nickel base alloys; testing; *SP640*; 1982 October. 454.

defect levels; dopant profiles; furnace anneal; ion implant; silicon; deep-level transient spectroscopy (DLTS); *NBS-GCR-81-364*.

defects; failure; fracture mechanics; girth welds; pipeline; plasticity; strength; stress; toughness; collapse; cracks; *21169*.

defects; motor vehicle equipment; motor vehicles; NHTSA; safety-related defects; safety standards; auto safety hotline; *SP621*; 1982 October. 212-214.

defects; optical properties; silicon; sulfur; chemical interactions; deep-level measurements; *20842*.

defect size measurement; fracture mechanics; girth welds; nondestructive evaluation; pipeline; radiography; regulation; *21189*.

definitions; hierarchy of standards; National Bureau of Standards; radiation; standards; traceability; calibration; *SP609*; 1982 February. 11-17.

definitions; history; international trade; laboratory accreditation; need; criteria; *SP632*.

definitive method; isotope dilution/mass spectrometry; mass spectrometry; stable isotope dilution analysis; statistical analysis; total cholesterol analysis; cholesterol analysis; *20796*.

deformation maps; high temperatures; proof testing; reliability; silicon nitride; structural ceramics; *NBSIR 81-2445*.

degenerate four-wave mixing; excited state spectrum; saturation spectrum; atomic mercury; *20983*.

degradation; hydrolysis; kinetics; polyester; polyurethane; acid; carbodiimide; *20972*.

degradation; outdoor exposures; simulated stagnation exposure; solar energy; absorptive coatings; accelerated laboratory exposures; *NBSIR 82-2583*.

degradation; polymers; polystyrene; pyrolysis; radiation flux; combustion; *NBS-GCR-82-403*.

degree sequence; graph; incidence sequence; loopless graph; partition; *J. Res. 87(1): 75-78*; 1982 January-February.

dehydration; energy storage; rehydration; solar; calcium-aluminum hydrates; calorimetry; *NBSIR 82-2531*.

deliverables; evaluation criteria; Federal agencies; language translators; portability; program inventory; RFP; statement of work; acceptance tests; conversion contracting; conversion problems; *SP500-90*.

Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; *NBSIR 82-2562*.

demand management; supply management; Thames Water Authority; United Kingdom; water conservation practices; *SP624*; 1982 June. 367-372.

demand reduction; drought emergency plans; educational programs; rural areas; water conservation; agricultural water uses; *SP624*; 1982 June. 465-469.

dendrites; interfaces; microcrystalline; nucleation; recalescence; solidification; undercooling; amorphous; cooling rate; crystalline; *21090*.

dense atomic vapors; electrons; ionization; laser excitation; resonant scattering; *21290*.

dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; *20836*.

densimeter; density; liquefied natural gas; methane; *TN1055*.

densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line;



normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; *Monogr. 169*.

densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; *Monogr. 170*.

densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; *TNI051*.

densities; lattice constants; powder patterns; reference intensities; standard; x-ray diffraction; crystal structure; *Monogr. 25, Section 19*.

density; density changes; density of solids; small samples; *J. Res. 87(3): 207-209; 1982 May-June*.

density; diffusion coefficient; drawing stress; low density polyethylene; plastic deformation; sorbate concentration; sorption; weight gain; concentration coefficient of diffusivity; *20876*.

density; enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; *TNI048*.

density; enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene; atactic; crystal; crystallinity; *JPCRD 11(2): 313-325; 1982*.

density; equation of state; expansivity; Pitzer's equations; *PVT*; volume; volumetric properties; apparent molal volume; aqueous sodium chloride solutions; compressibility; *JPCRD 11(1): 15-81; 1982*.

density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties; argon; critically evaluated data; *JPCRD 11(Suppl. 1): 354 pp.; 1982*.

density; liquefied natural gas; methane; densimeter; *TNI055*.

density; rare gas mixtures; spectral behavior; absorption spectrum; atomic masses; collision-induced absorption; concentration; correlation function; *21007*.

density at interface; distribution of polymer loops; interfacial thickness; polymer; polymer interfaces; adjacent reentry; *21063*.

density changes; density of solids; small samples; density; *J. Res. 87(3): 207-209; 1982 May-June*.

density measurement; density reference standard; liquefied natural gas; computational methods; computer programs; custody transfer; *20946*.

density measurement; float method; small solid objects; solid object density scale; *J. Res. 87(3): 197-206; 1982 May-June*.

density of solids; small samples; density; density changes; *J. Res. 87(3): 207-209; 1982 May-June*.

density of states; Hall effect; inversion layer; Landau level; MOSFET; *20942*.

density of states; indium doped silicon; isoelectronic; optical properties; photoluminescence; silicon; bound exciton; *21146*.

density reference standard; liquefied natural gas; computational methods; computer programs; custody transfer; density measurement; *20946*.

dental; dimensional change; expansion; alloy; amalgam; *21156*.

dental; instrumentation; pin and disc; restorative; wear; amalgam; apparatus; composite; *20916*.

dental amalgam; mercury; solubility of alloys in mercury; *20850*.

dental resins; fillers; acid etch; BIS-GMA; bonding; composites; *20847*.

dental resins; fillers; pedodontics; acid etch; adhesive bonding; composites; *20915*.

Department of Defense; Tri-Services Committee; building materials; building technology; construction; *21039*.

depletion of supply; myth of abundant water; quality degradation; water conservation; *SP624; 1982 June. 155-156*.

depth profiling; sputtering; surface analysis; thin films; x-ray spectroscopy; Auger spectroscopy; *20985*.

derailments; fatigue; freight car truck; railroad accidents; railroad freight car; railroad testing; reliability; *SP621; 1982 October. 3-17*.

derivative spectroscopy; diode laser; humidity; infrared; microcircuits; moisture; reliability; water vapor; *SP400-72; 1982 April. 105-109*.

description; passive; physical; property; sensor; solar test building; cross-section; *NBS-GCR-82-398*.

design; dividers; impulse measuring systems; resistor dividers; response time; voltage measurement; comparative measurements; *SP628; 1982 June. 34-45*.

design issues; hazard; pictograms; pictorial; safety; signs; standards; symbols; visual alerting; warning; communication; *BSS141*.

design of experiments; pooling of variance; weighted average; weighted least squares regression; ANOVA (within-between); components of variance; consensus values; *J. Res. 87(5): 377-385; 1982 September-October*.

desorption; electron stimulated desorption ion angular distribution; surface chemistry; surface structure; Al(111); ammonia; *21172*.

desorption; mass spectrometry; moisture evolution analysis; water sorption phenomenon; Cerdips; *SP400-72; 1982 April. 213-219*.

destruct heating; electricity production; energy recovery; incineration; New York City; resource recovery; solid waste management; steam production; *NBS-GCR-82-409*.

*Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *21326*.

detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; units; data reporting; *20888*.

detector calibrations; electron storage rings; electron synchrotrons; synchrotron radiation; *20776*.

determination of benzo[a]pyrene; multidimensional chromatographic analysis; on-line sequential liquid chromatographic analysis; polynuclear aromatic hydrocarbons; shale oil analysis; solvent refined coal; *20981*.

determinative ratios; FORTRAN program; metric symmetry; reduced cell; crystallography; data analysis; *21269*.

deuterated; methyl group; neutron scattering; nitromethane; reorientation; tunnel states; *20895*.

deuterium; electron stimulated desorption; ESD; ion kinetic energy distribution; methanol; methanol-d<sub>1</sub>; methanol-d<sub>3</sub>; *21133*.

deuterium lamp; silicon photodiode; specular reflectance; ultraviolet reflectance; absorption coefficient; black paint; *20989*.

deuterium on diamond; diamond(111) 1×1; EELS; electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; surface reconstruction; surface states; vibrational spectra; *21288*.

deuteron current; dielectric; neutron; proton current; pulsed generators; pulsed power; voltage determinations; *SP628; 1982 June. 104-117*.

developmentally disabled; elderly persons; evacuation; fire emergency planning; fire protection; group homes; mental disorders; board and care homes; *NBS-GCR-82-408*.

development methodology; documentation process; software documentation; *SP500-94; 1982 October. 16-22*.

device fabrication; electron-beam metallization; electron devices; ionizing radiation; microelectronics; process-related radiation damage; radiation dose; *21184*.

device installation programs; in-school education programs; residential water savings devices; *SP624; 1982 June. 449-452*.

dew point; failure; hybrid microcircuit; moisture; nichrome resistors; semiconductor devices; *SP400-72; 1982 April. 175-177*.

dew point; failure modes; hybrid manufacturing; moisture sources; adsorption; corrosion; *SP400-72; 1982 April. 117-125*.

dew point; hermetic packages; mass spectrometer; seam sealing; sensor chips; standards; water vapor; *SP400-72; 1982 April. 49-63*.

dew point; hermetic packages; moisture; packaging; water vapor; contamination; *SP400-72; 1982 April. 76-78*.

dew point; hygrometer; kinetics; microelectronic package; moisture; moisture level; relative humidity; sorption thermodynamics; absorption; adsorption; *SP400-72; 1982 April. 184-200*.

dew point; leakage current; capacitance; cooling rate; *SP400-72; 1982 April. 98-104*.

diagnostic controls; hydro-dynamic condition; lubrication systems; maintenance program; prevention; *SP640; 1982 October. 170-186*.

diagnostic radiology; general physics; medical physics; nonionizing radiation; nuclear medicine; radiation therapy; data handbook; *H138*.

diagnostics; faults; jet engines; monitoring; overhaul; productivity; vibration; balancing; *SP640; 1982 October. 115-129*.

diagnostics; ferrography; health monitoring; tribology; wear; wear debris analysis; *SP640; 1982 October. 466-475*.

diagnostics; technology in truck maintenance; truck maintenance aids; automated test equipment; *SP621; 1982 October. 201-211*.

diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail



- structures; rail vehicles; reliability; transportation systems; bridges; *SP621*.
- diamond(111) 1×1; EELS; electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; surface reconstruction; surface states; vibrational spectra; deuterium on diamond; *21288*.
- diatomic molecules; intensity factor; notation conventions; rotational line strengths; transition moments; *21274*.
- diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; *JPCRD 11(1)*: 83-99; 1982.
- dicyanomethylene; electrochemical; electron-transfer; mechanism; oxidation; reversible; salts; croconates; *21103*.
- dielectric; distribution; electrical failure; polyethylene; reflectometry; rf characteristics; transmission; treeing; aging; *21140*.
- dielectric; high voltage pulser; pulse generators; voltage probes; calibrations; capacitance-current; *SP628*; 1982 June. 59-68.
- dielectric; neutron; proton current; pulsed generators; pulsed power; voltage determinations; deuteron current; *SP628*; 1982 June. 104-117.
- dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion; chain conformation; crystalline transformation; Curie temperature; *21395*.
- dielectric constant; gravity effects; light scattering; critical phenomena in space; critical point; *20875*.
- dielectric constants; ellipsometry; niobium; optical constants; reflectance; refractive index; *21183*.
- dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; *Monogr. 169*.
- dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; *Monogr. 170*.
- dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; *TN1051*.
- dielectric properties; electrical properties; mechanical properties; thermal properties; thermodynamic properties; thermophysical properties; basal; chemical characterization; data compilation; *NBSIR 82-2587*.
- dielectrics; high voltage; insulation; liquids; shock waves; breakdown; *21352*.
- dielectric virial; intermolecular interactions; molecular constants; spectral shape; collision-induced dipoles; collision-induced spectra; *21167*.
- dielectronic recombination; multicharged ions; scattering; autoionization; collisions; *20880*.
- diesel engine performance; engine-generator efficiency; environmental impact; heat recovery; total energy system; absorption chillers; boiler performance; central utility plant; *NBSIR 82-2474*.
- diesel engine performance; engine-generator efficiency; integrated utility system; total energy systems-economic and engineering analysis; waste heat recovery; absorption chillers; boiler performance; *NBSIR 82-2483*.
- dietary enrichment; isotopes; mass spectrometry; neutron activation; plasma; zinc; *21374*.
- difference-frequency laser; Doppler-limited resolution; ethane; ground state constants; infrared spectrum; low temperature spectrum; torsional splittings; C-H stretching region; *J. Res. 87(3)*: 237-256; 1982 May-June.
- differential capacitance-voltage profiling; ion implantation; ranges of application and limitations; Schottky barrier diodes; SIMS and C-V profile comparisons; automatic C-V profiler analyses; carrier depth distributions; *SP400-71*.
- differential manometer; piston gage; pressure difference; pressure transducer; standards; calibration; *TN1052*.
- differential pressure; volume; volumetric test measures; water calibration; accountability tank; calibration; *TN1158*.
- differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; specific heat; thermosetting polymers; varnishes; adiabatic calorimetry; automated calorimetry; cross-linked polymer; *21032*.
- differential time transfer; frequency transfer; Global Positioning System; international time comparison; primary frequency standards; SI second; automatic time comparison; deep space network; *21204*.
- diffraction; Hanawalt search procedure; powder diffraction file; x ray; crystal data; *21271*.
- diffraction; high-energy x-rays; internal stress; neutron diffraction; nondestructive evaluation; residual stress; stress analysis; x-ray diffraction; *21359*.
- diffraction; isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation; activation analysis; crystal structure; *TN1160*.
- diffraction; macromolecular crystallography; neutrons; position-sensitive detectors; precision of data; x rays; *20982*.
- diffusion; diffusion coefficients; diffusion techniques; fused salts; molten salts; self-diffusion coefficients; *JPCRD 11(3)*: 505-693; 1982.
- diffusion; drift velocity; electrons; excitation; nitrogen; numerical calculation; transport; *21002*.
- diffusion; electrodes; examination; planar; stationary; unshielded; chronoamperometry; coefficient; *21361*.
- diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; *NBSIR 81-2314*.
- diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; oligomers; polyethylene; polypropylene; radiotracer; antioxidants; *NBSIR 82-2472*.
- diffusion; extraction; food packaging; heat stabilizers; migration; octyltins; poly(vinyl chloride); *21325*.
- diffusion; hydrophobic; moisture permeation; polymeric materials; solubility; *SP400-72*; 1982 April. 239-245.
- diffusion coefficient; drawing stress; low density polyethylene; plastic deformation; sorbate concentration; sorption; weight gain; concentration coefficient of diffusivity; density; *20876*.
- diffusion coefficients; diffusion techniques; fused salts; molten salts; self-diffusion coefficients; diffusion; *JPCRD 11(3)*: 505-693; 1982.
- diffusion flames; entrainment; fire plumes; flame size; flame structure; room fires; ceilings; *NBS-GCR-82-402*.
- diffusion flames; entrainment; heat flux; radiation; turbulence; buoyancy; cross-correlation; *NBSIR 82-2473*.
- diffusion flames; flame research; heat flux; methane; buoyancy; *NBS-GCR-82-367*.
- diffusion flames; flame stabilization; laser-induced fluorescence; polycyclic aromatic hydrocarbons; recirculation; soot formation; *21343*.
- diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; transactions; annual reports; *NBSIR 82-2575*.
- diffusion techniques; fused salts; molten salts; self-diffusion coefficients; diffusion; diffusion coefficients; *JPCRD 11(3)*: 505-693; 1982.
- diffusive crack growth; energy release rate; high temperature fracture; J-integral; Si-Al-O-N; singular integral equation; crack growth model; creep cavitation; *20931*.
- digital; Ethernet; local; microprocessor; network; serial; broadcast; coaxial; communication; contention; data; *20839*.
- digital communications equipment; digital techniques; equipment standards; law enforcement; mobile digital terminals; voice message traffic; *NBS-GCR-81-356*.
- digital controlled; encoder; law enforcement standard; selective signaling; squelch systems; tone-coding; decoder; *20991*.
- digital periodic integrator; electron probe microanalysis; glass standards; homogeneity testing; microhomogeneity; mineral glasses; standard reference material; chemical analysis; *SP260-74*.
- digital processing; dynamic testing; sine-wave testing; transient digitizer; transient response; waveform recorder; analog-to-digital converter; *SP634*; 1982 June. 27-34.
- digital sampling; fast Fourier transforms; sampling-rate drift; deconvolution; *SP634*; 1982 June. 47-53.
- digital techniques; equipment standards; law enforcement; mobile digital terminals; voice message traffic; digital communications equipment; *NBS-GCR-81-356*.
- digital-to-pneumatic conversion; direct digital control; energy controls; HVAC system; microprocessor control; pneumatic control system; velocity algorithm; building controls; *20995*.
- digitizer; dynamic testing; effective number of bits; frequency domain; quantizing error; signal-to-noise ratio; time domain; transient



recorder; analog-to-digital converter; *SP634*; 1982 June. 7-21.  
 digitizers; waveform calibration; waveform recording system; waveforms; calibration; *SP634*; 1982 June. 35-46.  
 digitizing anode; gamma ray; microchannel plate; multiple-pinhole mask; spectrometer; telescope; x ray; *21366*.  
 dimensional change; expansion; alloy; amalgam; dental; *21156*.  
 dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; *SP400-74*.  
 dimer; fungal pigment; metabolite of pathogenic fungi; single crystal x-ray diffraction; xanthomegnin; absolute configuration; crystal structure; *21313*.  
 dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; *20902*.  
 dimethyl sulfoxide; dosimetry; fibre optics; gamma-ray dosimetry; leuco cyanides; neutron dosimetry; optical waveguides; radiochromic dyes; anomalous dispersion; *20804*.  
 diode laser; humidity; infrared; microcircuits; moisture; reliability; water vapor; derivative spectroscopy; *SP400-72*; 1982 April. 105-109.  
 diode laser; infrared; spectra; air pollution; atmospheric chemistry; chlorine monoxide; ClO; *21303*.  
 diode lasers; Dunham coefficients; infrared; spectra; unstable molecules; bond distance; boron chloride; *20817*.  
 diode laser spectra; heterodyne frequency measurements; infrared spectroscopy; rotational constants; band centers; carbonyl sulfide; *20852*.  
 diode laser spectra; heterodyne spectroscopy; isotope enrichment isotope separation; SiF<sub>4</sub> spectra; CO<sub>2</sub> saturation spectra; *21216*.  
 diode recovery; high power measurements; high voltage; overshoot; power semiconductors; reverse-bias second breakdown; testing; voltage; clamping; *20849*.  
 diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; complexation; *21272*.  
 dioxirane; dipole moment; microwave spectrum; ozone-olefin reactions; structure; air pollution; *21340*.  
 dipolar emission; phase conjugacy; *21321*.  
 dipole moment; microwave spectrum; ozone-olefin reactions; structure; air pollution; dioxirane; *21340*.  
 dipole moments; electrically small; interference source; leakage; phase measurements; power measurements; radiation pattern; TEM cell; total radiated power; *TN1059*.  
 dipole polarizabilities; infrared intensities; molecular polarizabilities; vibrational polarizabilities; atomic polarization; *JPCRD 11(1)*: 119-133; 1982.  
 direct digital control; energy controls; HVAC system; microprocessor control; pneumatic control system; velocity algorithm; building controls; digital-to-pneumatic conversion; *20995*.  
 direct digital control; energy management and control systems; HVAC system control; parameter estimator; PI-controller; recursive least squares algorithm; self-tuning control algorithm; adaptive control; air handling unit; *NBSIR 82-2591*.  
 directional specular reflectance; reflectance specular; reflectance standards; second surface mirrors; solar reflectance; specular spectral reflectance; aluminum mirrors; *SP260-79*.  
 directory; ferrous metals; glass; nonferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles; *NBS-GCR-82-366*.  
 directory look-up; information retrieval; interactive processing; random access; computer indexing; data base; *TN1167*.  
 dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; *SP640*; 1982 October. 257-274.  
 dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; *SP640*; 1982 October. 257-274.  
 disaster recovery; empty shell; reciprocal aid; recovery center; redundant facilities; shared contingency facility; backup operations; contingency planning; *SP500-95*; 1982 October. 439-441.  
 discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; special relativity; surface charge conservation; transient propagation; arbitrary isotropic media; *21327*.  
 discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; special relativity; surface charge conservation; transient propagation; arbitrary isotropic media; discontinuity conditions; *21327*.  
 discrete Fourier transform; Fourier analysis; waveform; *21404*.  
 disk; main memory contention; modeling; packet switch; performance evaluation; simulation; trunk; WIN; analytical; capacity planning; central server; *SP500-95*; 1982 October. 97-106.  
 disk I/O; hardware monitoring; performance measurement; Shuttle Mission Simulator; UNIVAC; *SP500-95*; 1982 October. 217-230.  
 disks; drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus; surface roughness; surface topography; *TN1151*.  
 disk units; Federal Government computers; Federal minicomputers; Federal statistics; general purpose computers; magnetic tape units; terminals; *SP500-97*.  
 dislocation; glide; inclusion; kink; tetragonal; Burgers vector; defect; *20973*.  
 dispersancy; engine sequence tests; hot tube; laboratory bench tests; oxidation; solubilization; automotive crankcase oils; bench test procedures; catalysts; correlation; *21279*.  
 dispersion; effective charge; GaAs; gallium arsenid; infrared elasto-optic; optic phonon; oscillator strength; photoelastic; piezobirefringence; *21085*.  
 dispersion relation; perturbation theory; singularity; x-ray edge; *20960*.  
 dispersive bistability; fluctuations; nonequilibrium phase transitions; nonlinear optics; optical bistability; second harmonic generation; self pulsing; subharmonic generation; *20918*.  
 displacement measurements; kickback energy; optoelectronic measurement system; simulated kickback motion; volunteer test subjects; chain saw kickback motion; *NBSIR 82-2559*.  
 disposal costs; PAR factor; procurement; purchasing; recovered/recycled materials; resource recovery; bid-modifier; *NBS-GCR-82-400*.  
 disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; *21255*.  
 disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; *21254*.  
 dissociation; halocarbon; halogen; iron; adsorption; chemisorption; *21154*.  
 dissociation; hydrogen; iron; Ni(100); carbon monoxide; catalytic activity; *20987*.  
 dissociation; rhodium; carbon; carbon monoxide; chemisorption; *20962*.  
 dissolution of passive films; ellipsometry; iron; passive films; potentiostat; anodic oxidation; *20882*.  
 distorted wave approximation; fine structure transitions; Hund's coupling; WKB approximation; adiabatic electronic-rotational states; atomic scattering; *20786*.  
 distorted wave scattering theory; electron impact ionization of ions; iron; *20992*.  
 distorted wave theory; electron ionization; chlorine-like ions; *21367*.  
 distortion; microcomputer; rms value; sampling; signal period; algorithm; converter; *TN1159*.  
 distributed computing; high level protocols; networking performance; network protocols; protocol standards; standards; *21386*.  
 distributed control; integrated switching; packet switching survivability; alternate routing; circuit switching; communications networks; *NBSIR 82-2588*.  
 distributed control; message delay; network throughput; survivability; alternate routing; communications networks; *20994*.  
 distributed data; Government and industry; protocol standards; telecommunications; computer networks; *21265*.  
 distribution; electrical failure; polyethylene; reflectometry; rf characteristics; transmission; treeing; aging; dielectric; *21140*.  
 distribution functions; hard rods; molecular dynamics; non-ergodic; relaxation; velocity autocorrelation; *21283*.  
 distribution of polymer loops; interfacial thickness; polymer; polymer



interfaces; adjacent reentry; density at interface; 21065.

divider; high voltage measurements; impulse; step response; *SP628*; 1982 June. 26-33.

dividers; impulse measuring systems; resistor dividers; response time; voltage measurement; comparative measurements; design; *SP628*; 1982 June. 34-45.

DNA; multiphoton; nanosecond; photochemistry; picosecond; 21339.

documentation; documentation guidelines; documentation organizations; documentation procedures; structured interview; technical writing; case study; *SP500-94*; 1982 October. 143-151.

documentation; documentation standards; FADPUG; software engineering; system decomposition; top-down; *SP500-94*; 1982 October. 166-171.

documentation; Federal Information Processing Standards (FIPS); operations phase; automated data systems; computer programs; *SP500-94*; 1982 October. 68-75.

documentation; FIPS; guidelines; program documentation; software documentation; standards; *SP500-94*.

documentation; guidelines; life-cycle; software; specifications; standards; *SP500-87*.

documentation; hardware systems documentation; large computer manufacturers; microcomputers; periodical literature and documentation; software documentation; user's groups; verbal documentation; beginning computer users; *SP500-94*; 1982 October. 174-179.

documentation; Measurement Assurance Programs; measurement quality control; metrology management; special tests; calibration services; 20925.

documentation; operations manual; real-time system; *SP500-94*; 1982 October. 53-57.

documentation categories; documentation elements; uniform documentation standards; user guide documentation standards; user involvement; *SP500-94*; 1982 October. 43-45.

documentation elements; uniform documentation standards; user guide documentation standards; user involvement; documentation categories; *SP500-94*; 1982 October. 43-45.

documentation guidelines; documentation organizations; documentation procedures; structured interview; technical writing; case study; documentation; *SP500-94*; 1982 October. 143-151.

documentation life cycle; systems security; *SP500-94*; 1982 October. 131-142.

documentation organizations; documentation procedures; structured interview; technical writing; case study; documentation; documentation guidelines; *SP500-94*; 1982 October. 143-151.

documentation procedures; structured interview; technical writing; case study; documentation; documentation guidelines; documentation organizations; *SP500-94*; 1982 October. 143-151.

documentation process; software documentation; development methodology; *SP500-94*; 1982 October. 16-22.

documentation requirements; integrated design and documentation; computer maintained documentation; *SP500-94*; 1982 October. 110-118.

documentation standards; FADPUG; software engineering; system decomposition; top-down; documentation; *SP500-94*; 1982 October. 166-171.

documentation standards; information processing system standards; project management standards; *SP500-94*; 1982 October. 160-164.

documentation standards; internal documentation; software engineering; automated documentation; *SP500-94*; 1982 October. 119-125.

documentation standards; machine-readable data files (MRDF); bibliographic control; bibliographic standards; computer software; *SP500-94*; 1982 October. 183-188.

documentation standards; software compatibility; user experience; *SP500-94*; 1982 October. 8-15.

document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; concept relations; co-occurrence; 21250.

document types; DoD standard; management options; *SP500-94*; 1982 October. 152-156.

DoD standard; management options; document types; *SP500-94*; 1982 October. 152-156.

DoE-2 energy analysis computer program: monthly average earth temperature; thermal response factors; building heat transfer; *NBSIR 81-2420*.

donor impurities; Germi energy; silicon; Yukawa potential; bandgap narrowing; band states; 20921.

donors; effective mass; energy dispersion; impurities; silicon; valence states; Yukawa potential; bandgap narrowing; Bargmann potential; conduction states; 20855.

doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; building fires; compartment fires; 21121.

door security; entry control; hardware; installation; locking device classification; lock operation; characteristics; *NBSIR 81-2233*.

dopant profile control; ion channeling; ion implantation; silicon; silicon dioxide; boron; 20824.

dopant profiles; furnace anneal; ion implant; silicon; deep-level transient spectroscopy (DLTS); defect levels; *NBS-GCR-81-364*.

dopant profiles; gallium doped silicon; resistivity profiles silicon; spreading resistance; thyristor; aluminum-doped silicon; 21083.

doping; impurity states; midgap absorption; nonhydrogenic states; polaron; polyacetylene; soliton; 21104.

Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; satellite; shuttle time; time and frequency metrology; time comparisons; 21201.

Doppler-limited resolution; ethane; ground state constants; infrared spectrum; low temperature spectrum; torsional splittings; C-H stretching region; difference-frequency laser; *J. Res. 87(3)*: 237-256; 1982 May-June.

dose-averaged energy loss; energy deposition spectra; energy distributed neutron spectra; frequency averaged energy loss; microdosimetric parameters; bin-averaged cross sections; 21029.

dose equivalent; dosimeter; neutron; remmeter; room return; air scatter; calibration; californium; *SP633*.

dose equivalent; field measurement; Health Physics Society; neutrons; photons; standard; testing program; conversion factors; 20813.

dose rate; dosimetry; dyes; film dosimetry; gamma rays; humidity effects; leucocyanines; pulse radiolysis; radiation processing; radiochromic dyes; bleaching of dyes; 20844.

dosimeter; neutron; remmeter; room return; air scatter; calibration; californium; dose equivalent; *SP633*.

dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; *SP609*; 1982 February. 171-178.

dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; 20974.

dosimeters; NRC; pilot study; sources; standard; traceability; *SP609*; 1982 February. 145-148.

dosimetry; dye dosimetry; electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; 20902.

dosimetry; dyes; film dosimetry; gamma rays; humidity effects; leucocyanines; pulse radiolysis; radiation processing; radiochromic dyes; bleaching of dyes; dose rate; 20844.

dosimetry; dyes; gamma radiation; plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; relative humidity effects; temperature effects; 20975.

dosimetry; electromagnetic; exposure; nonionizing; radiation; radiofrequency; regulation; safety; standards; bioeffects; 21038.

dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; *SP609*; 1982 February. 171-178.

dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; 20974.

dosimetry; electrons; Monte Carlo; point-monodirectional beams; superposition; treatment planning; *NBSIR 82-2451*.

dosimetry; environmental; intercomparison; standards; thermoluminescence; calibration; *SP609*; 1982 February. 111-116.

dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; radiochromic dye; alanine; biographic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; 20889.

dosimetry; ethylene vinyl acetate; initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon; crosslinking; 20900.

dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy;



survey; teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; *SP609*; 1982 February. 89-97.

dosimetry; fibre optics; gamma-ray dosimetry; leuco cyanides; neutron dosimetry; optical waveguides; radiochromic dyes; anomalous dispersion; dimethyl sulfoxide; *20804*.

dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosaniline; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; *20905*.

dosimetry standards; iodine-125; iridium-192; radium; standards; brachytherapy; calibration; cesium-137; *21311*.

double electron; excitation; sodium; 2s; continuum; *21331*.

double hashing; requirements; retrieval; Tharp's algorithm; assignment; Brent's algorithm; *21248*.

double kink nucleation; edge dislocation pileup; equilibrium jog array; Mode I brittle crack; activation energy for double kink formation; boundary conditions for atomic simulations; brittle crack growth rate; *21193*.

double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; system parameters; transportable computer software; ANSI FORTRAN; computer independent; *TN1163*.

double resonant charge exchange; ion-ion collision processes; multicharged ions theoretical; *21149*.

doublet inversions; relativistic effects; spectroscopy; *21057*.

doubly charged ions; mass spectrometry; Penning ion source; atomic negative ions; *21370*.

DP accounting; pricing; billing systems; chargeback systems; charging systems; cost accounting; costing; *SP500-95*; 1982 October. 425.

drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus; surface roughness; surface topography; disks; *TN1151*.

drag; oscillatory flow; phase dependent; ripple; sand; sea bed; stress; time dependent; unsteady; water tunnel; waves; *21332*.

drainage; solid transport; unsteady flow; computer based model; *BSS139*.

drainage piping; transient pipe flow; transient solid motion, pipe flows; computational method, fluid mechanics; *21081*.

drain-source resistance; electron devices; gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; power transistors; radiation effects; semiconductor devices; VDMOS; *21000*.

drawing stress; low density polyethylene; plastic deformation; sorbate concentration; sorption; weight gain; concentration coefficient of diffusivity; density; diffusion coefficient; *20876*.

drawn polyethylene; gauche defect; Raman scattering; straight chain section; accordion-type oscillation; *20790*.

dressed-atoms; inelastic cross-sections; laser; laser-induced collisions; radiation theory; stimulated emission; atomic collisions; close-coupled scattering theory; *21347*.

drift velocity; electrons; excitation; nitrogen; numerical calculation; transport; diffusion; *21002*.

drill breakage; Drill-Up; drill wear; time-domain analysis; tool breakage; vibration sensing; *NBSIR 82-2590*.

drill failure prediction; drill wear; finished dimensions; improper drilling; time-domain analysis; tool failure; tool wear; vibration signatures; automated manufacturing; *20795*.

drilling; energy; field tests; foundation design; hammer; in-situ tests; Standard Penetration Test; boring; *20951*.

drills; in situ test; penetration tests; practice; samplers; soil tests; standard penetration tests; *20867*.

Drill-Up; drill wear; time-domain analysis; tool breakage; vibration sensing; drill breakage; *NBSIR 82-2590*.

drill wear; finished dimensions; improper drilling; time-domain analysis; tool failure; tool wear; vibration signatures; automated manufacturing; drill failure prediction; *20795*.

drill wear; time-domain analysis; tool breakage; vibration sensing; drill breakage; Drill-Up; *NBSIR 82-2590*.

drop calorimetry; enthalpy; heat capacity; high temperature; standard reference material; synthetic sapphire; aluminum oxide; corundum; *J. Res. 87(2): 159-163*; 1982 March-April.

drought emergency plans; educational programs; rural areas; water conservation; agricultural water uses; demand reduction; *SP624*; 1982 June. 465-469.

drought-tolerant plant; water conservation; consumer education; *SP624*; 1982 June. 27-36.

drug development; drug regulation; innovation; post-marketing surveillance; regulatory experiments; *NBS-GCR-ETIP 82-99*.

drug regulation; innovation; post-marketing surveillance; regulatory experiments; drug development; *NBS-GCR-ETIP 82-99*.

DSNAME ENQUEUE conflict management; MVS SRM; resource-sensitive job scheduling; service levels; SMF exits; workload scheduling; batch; *SP500-95*; 1982 October. 297-311.

D-subminiature connector; interchangeability; law enforcement; microphone cable; mobile transceiver; performance standard; cable assembly; cable connector; control cable; control head; *20904*.

dual acceptance criteria; mixed sampling plan; order statistics; statistical methods; acceptance probability; compliance sampling; *J. Res. 87(6): 485-511*; 1982 November-December.

ductile fracture; leak vs. break; part-through crack; pipeline fracture; plastic necking instability; progressive crack growth; crack initiation; crack opening displacement; *SP621*; 1982 October. 153-164.

ductile materials; fatigue; fractures; machines; stress systems; tension loading; brittle materials; *SP621*; 1982 October. 196-200.

Dunham coefficients; infrared; spectra; unstable molecules; bond distance; boron chloride; diode lasers; *20817*.

durability; duration of load; life data; life distribution; reliability; service life; wood; *20809*.

durability; natural weathering; solar collectors; solar energy; solar energy transmittance; tensile properties; weathering of cover plates; artificial weathering; cover plate materials; *TN1170*.

durability; plastic containment materials; solar energy systems; standards; *NBSIR 82-2533*.

duration of load; life data; life distribution; reliability; service life; wood; durability; *20809*.

dyadic Green functions; electromagnetic scattering; integral equations; perfect conductors; transient electromagnetic fields; wave equations; *TN1157*.

dye dosimetry; electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; *20902*.

dye laser; mode-locked; picosecond; pulse emission; streak-camera; tunable; *21348*.

dye laser stabilization; laser frequency stabilization; laser spectroscopy; *21115*.

dyes; film dosimetry; gamma rays; humidity effects; leucocyanides; pulse radiolysis; radiation processing; radiochromic dyes; bleaching of dyes; dose rate; dosimetry; *20844*.

dyes; gamma radiation; plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; relative humidity effects; temperature effects; dosimetry; *20975*.

dynamical diffraction theory; x-ray extinction; x-ray imaging; x-ray topography; *21258*.

dynamic analysis; formal analysis; software testing; software verification; static analysis; test coverage; validation; V,V&T techniques; V,V&T tools; automated software tools; *SP500-93*.

dynamic analysis; performance monitoring; program analysis; program instrumentation; software tools; coverage analysis; *SP500-95*; 1982 October. 195-202.

dynamic analysis; programming aids; software development; software engineering; software tools; static analysis; compilers; *NBSIR 81-2423*.

dynamic analysis; programming aids; software development; software engineering; software tools; static analysis; compilers; *NBS-GCR-82-376*.

dynamic intrinsic viscosity; internal viscosity; necklace model; polystyrene; Aroclor; *21059*.

dynamic performance of buildings; energy conservation; heat transfer in buildings; night space cooling; night ventilation; passive solar heating; building thermal mass; *BSS137*.

dynamic response; linearity; metrology support; phase angle calibration; signal sampling; stability; waveform synthesis; ac-dc difference; data conversion; *21027*.

dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; residential furnaces; room temperature; thermal response factors; thermostat control; burner on-time; cyclic rates; *20903*.

dynamic standards; transport standards; automatic test equipment; calibration; calibration traceability; *21025*.

dynamic test; laboratory test; sand; shear test; simple shear test; size effects; cyclic loading; *20857*.

dynamic testing; effective number of bits; frequency domain; quantizing error; signal-to-noise ratio; time domain; transient recorder; analog-to-digital converter; digitizer; *SP634*; 1982 June. 7-21.



dynamic testing; high resolution; settling time; step response; analog-to-digital converters; code transition levels; converter testing; 20908.

dynamic testing; sine-wave testing; transient digitizer; transient response; waveform recorder; analog-to-digital converter; digital processing; *SP634*; 1982 June. 27-34.

dysprosium; energy levels; erbium; gadolinium; neodymium; samarium; spectrum; tantalum; tungsten; ytterbium; barium; 20845.

## E

earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; *BSS138*.

earthquake requirements; energy conservation; existing buildings; rehabilitation; building accessibility; building rehabilitation guidelines; code enforcement; 21385.

echo-ranging transducer; industrial robots; robots; safety; sensors; ultrasonic; 20977.

economic analysis; energy economics; life-cycle costing; solar energy; building economics; commercial buildings; *NBSIR 82-2540*.

economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; *SP631*.

economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; building economics; 20909.

economic analysis; marginal price; water conservation; water pricing; water rate schedules; average price; 21142.

economic analysis; photomask linewidth measurements; semiconductors; accurate measurements; benefit-cost analysis; cost savings; *NBSIR 82-2458*.

economic assistance; innovation; procurement; regulation; research and development; technology policy; administrative experiments; *NBS-GCR-ETIP 82-100*.

economic benefits; industry; International System of Units (SI); metric system; status and future; 21120.

economics; energy conservation; housing; insulation; space heating and cooling costs; space heating and cooling requirements; architecture; building design; cost-benefit analysis; *NBSIR 81-2380*.

eddy current; failure prevention; ferro-magnetic alloys; inspection; metal distress; metal parts; NDE; nickel base alloys; testing; defect detection; *SP640*; 1982 October. 454.

eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; and ultrasonics; acoustic emission; *NBSIR 82-2449*.

eddy currents; leak rate measurements; liquid penetrants; magnetic particles; neutron radiography; traceable NDE; visual acuity; acoustic emission; 21166.

eddy currents; liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; radiography; tire inspection; ultrasonics; visual-optical; acoustic emission; 20957.

edge dislocation pileup; equilibrium jog array; Mode I brittle crack; activation energy for double kink formation; boundary conditions for atomic simulations; brittle crack growth rate; double kink nucleation; 21193.

educational programs; rural areas; water conservation; agricultural water uses; demand reduction; drought emergency plans; *SP624*; 1982 June. 465-469.

education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures; *SP629*.

EELS; electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; surface reconstruction; surface states; vibrational spectra; deuterium on diamond; diamond(111) 1×1; 21288.

effective charge; GaAs; gallium arsenide; infrared elasto-optic; optic phonon; oscillator strength; photoelastic; piezobirefringence; dispersion; 21085.

effective core potentials; excimer; rare-gas halide; transition moments; blue-green laser; 21309.

effective mass; energy dispersion; impurities; silicon; valence states;

Yukawa potential; bandgap narrowing; Bargmann potential; conduction states; donors; 20855.

effective number of bits; frequency domain; quantizing error; signal-to-noise ratio; time domain; transient recorder; analog-to-digital converter; digitizer; dynamic testing; *SP634*; 1982 June. 7-21.

effective potentials; spin-orbit coupling; *ab initio* effective spin-orbit operators; 21333.

effective potentials; spin-orbit coupling; *ab initio* effective spin-orbit operators; 21338.

effects simulator; nuclear weapons; bremsstrahlung radiation; Casino Facility; *SP628*; 1982 June. 118-132.

efficiency data; half lives; measurement uncertainties; photon probabilities per decay; relative photon-emission probabilities; compilation; *SP626*.

efficient evaluation algorithms; modelling; queueing network models; *SP500-95*; 1982 October. 437.

egress; elevators; handicapped; pressurization; smoke control; stairwells; building fires; 21226.

egress; elevators (lifts); evacuation; handicapped; pressurization; smoke control; stairwells; building fires; *NBSIR 82-2507*.

egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; building design; building fires; building management; *NBS-GCR-82-383*.

egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits; combustion products; compartment fires; *NBSIR 82-2578*.

egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; building fires; compartment fires; doors; 21121.

egress; ingress; integrated circuit package; moisture; monolayer buildup; *SP400-72*; 1982 April. 258-270.

EHV revenue metering; energy metering; field calibration; metering accuracy CCVTs; 500 kV; 500 kV substation measurements; CCVTs; *TN1155*.

EHV substations; error sources; high voltage measurements; revenue metering; calibration; CCVT; *NBSIR 81-2360*.

eigenvalues; elliptic equations; finite elements; multi-level iterations; triangulations; adaptive meshes; 20823.

elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; free-free transitions; Nd laser; photon-assisted transitions; angular distributions; close-coupling approximation; CO<sub>2</sub> laser; 20787.

elastic anisotropy; flaw detection; horizontally polarized shear waves; stainless steel; ultrasonic testing; 21253.

elastic anisotropy; nondestructive evaluation; stainless steel; ultrasonic scattering; ultrasonic waves; acoustic waves; 21224.

elastic constants; elastic-wave scattering; fiber-reinforced composites; particulate composites; wave propagation; composites; 20884.

elastic constants; error propagation; matrix inversion; physical property; 20818.

elastic constants; flywheel; iron alloy; mass density; mechanical property; titanium alloy; alloy; aluminum alloy; *NSRDS-NBS61, Part V*.

elastic constants; glass-epoxy; graphite-epoxy; internal friction; shear modulus; sound velocity; ultrasonic wave; Young's modulus; boron-aluminum; 20868.

elastic constants; low-temperature; magnetic transition; physical properties; Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; 21198.

elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; 21175.

elasticity coefficients; nematic liquid crystals; 20822.

elastic properties; flux deviation; moisture effects; composites; 21196.

elastic scattering; electron-impact ionization; electrons; photons; stopping power; transport; bremsstrahlung; cross sections; *NBSIR 82-2572*.

elastic scattering cross section; inelastic scattering cross section; spin-dependent scattering; 21101.

elastic wave; nondestructive evaluation; Rayleigh wave; transducer; ultrasonic; acoustic emission; 21098.

elastic waves; flaws; nondestructive evaluation; nondestructive testing; scattering; variational method; 21239.

elastic-wave scattering; fiber-reinforced composites; particulate composites; wave propagation; composites; elastic constants; 20884.

elderly persons; evacuation; fire emergency planning; fire protection;



group homes; mental disorders; board and care homes; developmentally disabled; *NBS-GCR-82-408*.

electrical; electrochemical; mechanism;  $\pi$ -acceptors; semiconduction; conductivity; croconates; crystallographic; *J. Res. 87(3)*: 257-260; 1982 May-June.

electrical; impedance; polyacetylene; transport; conductivity; 20853.

electrical breakdown; high speed photography; Kerr effect; liquid breakdown; nitrobenzene; partial discharges; streamers; transient phenomena; 21328.

electrical conductivity; nonlocal process; surface conductivity; surface phenomena; adsorbed water; *SP400-72*; 1982 April. 149-164.

electrical failure; polyethylene; reflectometry; rf characteristics; transmission; treeing; aging; dielectric; distribution; 21140.

electrical insulation; high voltage; liquids; partial discharge; polydimethylsiloxanes; breakdown; 21130.

electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; transfer standard; absolute calibration; absolute quantum yield; actinometry; amplitude stabilized lasers; 21045.

electrically small; interference source; leakage; phase measurements; power measurements; radiation pattern; TEM cell; total radiated power; dipole moments; *TN1059*.

electrical measurements; electromagnetic pulse; fusion; nuclear effects simulation; particle beam technology; pulse power; transients; voltage measurements; current measurement; *SP628*.

electrical properties; mechanical properties; thermal properties; thermodynamic properties; thermophysical properties; basalt; chemical characterization; data compilation; dielectric properties; *NBSIR 82-2587*.

electrical properties; piezoelectricity; poling; pyroelectricity; tetrafluoroethylene; vinylidene fluoride; charge transport; copolymer; 20840.

electrical property; low-temperature; standard; superconductor; critical current; critical temperature; 21014.

electrical property; magnetic field; measurement; niobium; superconductor; tin; titanium; copper; critical current; 21218.

electrical property; metals; polymers; resistance; resistivity; review; alloys; conductivity; *TN1053*.

electrical test structure; gated diode; generation lifetime; integrated gated-diode electrometer; integrated test structure; leakage current; open-circuit voltage decay; surface recombination velocity; 21143.

electrical transformer; interference; quantum mechanics; uncertainty relations; vector potential; Bohm-Aharonov; 20794.

electrical transient phenomena; transient recording laboratory; transient surges; *SP628*; 1982 June. 355-364.

electric dipole moment; microwave spectrum; molecular structure; rotational spectrum; structure; borane monoammoniate; 21337.

electricity production; energy recovery; incineration; New York City; resource recovery; solid waste management; steam production; destruct heating; *NBS-GCR-82-409*.

electric strip heaters; environmental conditions; indoor testing; modeling; NBS; solar; solar domestic hot water system; stratification; test method; ASHRAE Standard 95; collectors in parallel; *BSS140*.

electric utility rate regulation; Experimental Technology Incentives Program; innovation; productivity analysis; computerized analysis; *NBSIR 80-2046*.

electrochemical; electron-transfer; mechanism; oxidation; reversible; salts; croconates; dicyanomethylene; 21103.

electrochemical; mechanism;  $\pi$ -acceptors; semiconduction; conductivity; croconates; crystallographic; electrical; *J. Res. 87(3)*: 257-260; 1982 May-June.

electrochemical equivalent; Faraday constant; fundamental constants; silver; silver coulometer; atomic weight; atomic weight of silver; coulometer; *J. Res. 87(1)*: 21-22; 1982 January-February.

electrochemical techniques; localized corrosion; localized corrosion mechanism; pitting; accelerated testing; crevice corrosion; *NBSIR 82-2477*.

electrochemistry; frequency analysis; rectification; alternating voltage; charge-transfer; corrosion; 20886.

electrochemistry; membranes; olfaction; protein separation; chemical analysis; *NBS-GCR-82-378*.

electrochemistry; passivity; repassivation; surface modification; breakdown of passivity; corrosion; 20928.

electrodeposition; metallic glasses; nickel-phosphorus; steel; wear; wear testing; chromium; coatings; 21232.

electrodeposition; nickel adhesion; plating; aluminum; anodizing; 21267.

electrode processes; N-methylpyridinium iodide; pyridine derivatives; Raman spectroscopy; silver electrode; surface-enhanced Raman spectroscopy; adsorption; 21262.

electrodes; examination; planar; stationary; unshielded; chronoamperometry; coefficient; diffusion; 21361.

electroless nickel plating; nickel-phosphorus alloy; ultra-black coating; *U.S. Patent 4,361,630*.

electrolyte; excess Gibbs energy; isopiestic; nickel nitrate; osmotic coefficient; solubility; solutions; thermodynamics; activity coefficient; 21234.

electrolyte; excess Gibbs energy; osmotic coefficient; solutions; thermodynamic properties; activity coefficient; critical evaluation; 20936.

electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; conductivity; *NBSIR 81-2356*.

electrolytes; excess Gibbs energy; isopiestic; osmotic coefficient; potassium carbonate; solubility; solutions; thermodynamics; activity coefficient; 21233.

electrolyte theories; models; osmotic coefficient; polyvalent electrolytes; thermodynamics properties; activity coefficient; correlation; critical evaluation; 20935.

electromagnetic; exposure; nonionizing; radiation; radiofrequency; regulation; safety; standards; bioeffects; dosimetry; 21038.

electromagnetic compatibility measurements (EMC); low-Q chambers; reverberation chambers; transverse electromagnetic cells; buried electromagnetic enclosures; 21061.

electromagnetic field; field intensity meter; isotropic antenna; radio frequency radiation; 20885.

electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; special relativity; surface charge conservation; transient propagation; arbitrary isotropic media; discontinuity conditions; discontinuous radiation; 21327.

electromagnetic pulse; fiber optics; Marx generators; Remote Command Data Link; *SP628*; 1982 June. 310-315.

electromagnetic pulse; field jumps; Lorentz transformation; special relativity; surface charge conservation; transient propagation; arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; 21327.

electromagnetic pulse; fusion; nuclear effects simulation; particle beam technology; pulse power; transients; voltage measurements; current measurement; electrical measurements; *SP628*.

electromagnetic radiated emissions measurements; open-field site; transverse electromagnetic cells; 21062.

electromagnetics; encoders; pulse; standards; waveform generation; waveform measurements; waveform recorder; converters; *SP634*.

electromagnetic scattering; integral equations; perfect conductors; transient electromagnetic fields; wave equations; dyadic Green functions; *TN1157*.

electromagnetic waveform measurements; Automated Pulse Measurement System; *SP628*; 1982 June. 392-407.

electromagnetic waves; graded materials; inhomogeneous media; jellium; optical reflections; reflection coefficient; Riccati equation; surface reflections; wave impedance; *TN1171*.

electron; Fermi gas model; Feynman diagrams; meson exchange current; nucleus; photon; pion; 21345.

electron; photon; transport; bremsstrahlung; cross sections; data base; 21384.

electron-atom scattering; electron impact ionization; lithium atom; *J. Res. 87(1)*: 49-51; 1982 January-February.

electron avalanches; gas chromatograph; mass spectrometer; SF<sub>6</sub>; streamer pulses; sulfurhexafluoride; water vapor; corona discharges; 21379.

electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; 20902.

electron beam; high energy; ionization chamber; photon beam; radiation therapy; absorbed dose; calibration; 20894.

electron beam; interface velocity; rapid solidification; stability; surface melting; aluminum-silver alloys; cellular growth; 21263.

electron-beam metallization; electron devices; ionizing radiation; microelectronics; process-related radiation damage; radiation dose; device fabrication; 21184.

electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; *SP609*; 1982 February. 171-178.



electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; 20974.

electron devices; ellipsometric; integrated circuits; aluminum-oxide interlayer; Auger; capacitance-voltage; 20827.

electron devices; gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; power transistors; radiation effects; semiconductor devices; VDMOS; drain-source resistance; 21000.

electron devices; ionizing radiation; microelectronics; process-related radiation damage; radiation dose; device fabrication; electron-beam metallization; 21184.

electron diffraction; polarized low energy; spin-orbit splitting; surface potential barrier tungsten (100); surface resonance; 20976.

electron energy loss; electron impact excitation; electron spectroscopy; generalized oscillator strength; 21058.

electron energy-loss spectra; incident-energy dependence; nickel; 20860.

electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; surface reconstruction; surface states; vibrational spectra; deuterium on diamond; diamond(111) 1×1; EELS; 21288.

electron flux; Antares Electron Gun; beam current; SP628; 1982 June. 256.

electron-hole pairs; Franck-Condon factors; surface reactions; trajectories; vibrational spectroscopy; 21178.

electron-hydrogen scattering; Feshbach resonances; free-free transitions; Nd laser; photon-assisted transitions; angular distributions; close-coupling approximation; CO<sub>2</sub> laser; elastic and inelastic; 20787.

electronic balance; feedback control; fluid density; hydrostatic weighing; magnetic suspension; capacitance sensing; 21207.

electronic packages; hermetic test; leak testing; back pressurization; SP400-73.

electronic packages; hermetic test; leak testing; back pressurization; 20856.

electronics; noise; photon detector; rectifier; solid state devices; transistor; TN1169.

electronic spectra; infrared; microwave; molecular spectroscopy; rotational spectra; ultraviolet; vibrational spectra; visible; 21388.

electronic spectra; predissociation; transition probability assignment; Ca<sub>2</sub>; charge density; 21310.

electronic structure; multiconfiguration; photodissociation; self-consistent field theory; ab initio; 21308.

electron impact; excitation-autoionization; Ga<sup>+</sup>; ionization; Zn<sup>+</sup>; crossed beams; 21071.

electron impact; excitation-autoionization; ionization; Mg<sup>+</sup>; Na iso-sequence; Si<sup>3+</sup>; Al<sup>1+</sup>; crossed beams; cross sections; 21073.

electron impact excitation; electron spectroscopy; generalized oscillator strength; electron energy loss; 21058.

electron impact excitation; lifetime; polarization; Zn<sup>+</sup>; crossed beams; cross sections; 21072.

electron-impact ionization; electrons; photons; stopping power; transport; bremsstrahlung; cross sections; elastic scattering; NBSIR 82-2572.

electron impact ionization; ionization potential; photoelectron spectroscopy; photoionization; spectroscopy; appearance potential; charge transfer spectrum; NSRDS-NBS71.

electron impact ionization; lithium atom; electron-atom scattering; J. Res. 87(1): 49-51; 1982 January-February.

electron impact ionization of ions; iron; distorted wave scattering theory; 20992.

electron-ion collisions; excitation; Ga II; resonance line; absolute cross section; crossed beams; 21317.

electron ionization; chlorine-like ions; distorted wave theory; 21367.

electron ionization of positive ions; atomic scattering theory; 20869.

electron-ion pairs; electron shells; molecules; photoionization; atoms; cross section; 21056.

electron microscope; energy dispersive x-ray spectrometry; image analysis; scanning transmission; selected area electron diffraction; transmission electron microscope; SP619; 1982 March. 207-210.

electron microscope; error; fibrils; laboratories; asbestos analysis; SP619; 1982 March. 162-168.

electron microscope; fiber concentrations; standard samples; asbestos fiber; biological samples; SP619; 1982 March. 53-67.

electron microscopical method; environment; EPA Provisional Methodology; particle technologist; asbestos minerals; SP619; 1982 March. 183-189.

electron microscopic analysis; EPA-NBS agreement; methodology manual; standardized measurement protocol; airborne asbestos fibers; SP619; 1982 March. 1-4.

electron microscopy; electron probe microanalysis; ion probe; laser Raman probe; microanalysis; microscopy; 20897.

electron microscopy; fiber counts; sample preparation; asbestos identification; asbestos standard; SP619; 1982 March. 138-144.

electron microscopy; fibrous minerals; asbestos standards; asbestos statistics; SP619.

electron microscopy; filter; isooctane; liquid separation; chrysotile asbestos; SP619; 1982 March. 85-90.

electron microscopy; lubricant additive; solid lubricant; wear; wear debris; antimony thioantimonate; NBSIR 82-2545.

electron microscopy; occupational monitoring; optical microscopy; analysis; asbestos; SP619; 1982 March. 132-137.

electron-molecule collisions; MEAN approximation; polar molecules; 20952.

electron polarization; electron scattering resonances; spin; spin-orbit interaction; surface magnetism; 20891.

electron probe microanalysis; glass standards; homogeneity testing; microhomogeneity; mineral glasses; standard reference material; chemical analysis; digital periodic integrator; SP260-74.

electron probe microanalysis; ion probe; laser Raman probe; microanalysis; microscopy; electron microscopy; 20897.

electron production; multiple ionization; vacancies; x-ray emission; 21261.

electrons; excitation; measurement; x-ray emission lines; x-ray photoelectron spectra; crystal spectroscopy; 21330.

electrons; excitation; nitrogen; numerical calculation; transport; diffusion; drift velocity; 21002.

electrons; experimental; inelastic scattering; O<sub>2</sub>; Rydberg series; angular distributions;  $c^4\Sigma_u^+$  limit; 21077.

electrons; instrumentation; photon detectors; SURF-II; calibration; 21053.

electrons; ionization; laser excitation; resonant scattering; dense atomic vapors; 21290.

electrons; Monte Carlo; point-monodirectional beams; superposition; treatment planning; dosimetry; NBSIR 82-2451.

electrons; photons; stopping power; transport; bremsstrahlung; cross sections; elastic scattering; electron-impact ionization; NBSIR 82-2572.

electrons; positrons; radiation yield; radiative stopping power; range; collision stopping power; NBSIR 82-2550.

electron scattering; Fermi gas model; nuclear response function; nuclei; nucleons; quasi-free; charge magnetization; Coulomb sum rule; 21400.

electron scattering resonances; spin; spin-orbit interaction; surface magnetism; electron polarization; 20891.

electron shells; molecules; photoionization; atoms; cross section; electron-ion pairs; 21056.

electron spectroscopy; generalized oscillator strength; electron energy loss; electron impact excitation; 21058.

electron spin polarization; ferromagnetic glass; scanning electron microscopy; secondary electron emission; spin analyzer; spin polarized secondary electron; 21360.

electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosaniline; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; 20905.

electron stimulated desorption; ESD; ion kinetic energy distribution; methanol; methanol-d<sub>1</sub>; methanol-d<sub>3</sub>; deuterium; 21133.

electron stimulated desorption; ESD; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS; 20832.

electron stimulated desorption; ESDIAD; low energy electron diffraction; thermal desorption; adsorption; carbon monoxide on Ni(111); 21100.

electron stimulated desorption ion angular distribution; surface chemistry; surface structure; Al(111); ammonia; desorption; 21172.

electron storage rings; electron synchrotrons; synchrotron radiation; detector calibrations; 20776.

electron synchrotrons; synchrotron radiation; detector calibrations; electron storage rings; 20776.

electron transfer; electron transfer model; interacting multiple redox centers; interaction energies; nearest neighbor interactions; 20837.

electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; NSRDS-



electron-transfer; mechanism; oxidation; reversible; salts; croconates; dicyanomethylene; electrochemical; 21103.

electron transfer model; interacting multiple redox centers; interaction energies; nearest neighbor interactions; electron transfer; 20837.

electro-optical measurements; frequency response; interferometric measurements; Kerr effect; Pockels effect; polarization; accuracy; calibration; SP628; 1982 June. 1-19.

electro-optic modulation; hydrogenated amorphous silicon; optical transmittance; refractive index; scattering matrix; thin film; transmittance extrema; NBSIR 81-1652.

electroplating; Great Lakes region; hazardous waste management; paint manufacturing; resource recovery; solvent recovery; steel manufacturing; NBS-GCR-82-405.

electrostatic potential; high efficiency air particulate (HEPA) filters; ion counters; ion density; measurement; net space charge; NBSIR 82-2517.

elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; 21254.

elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; 21255.

elements; enthalpy; entropy; evaluated data; heat capacity; thermodynamics; 20819.

element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; 21272.

elevated temperature; heat transfer liquid degradation kinetics; simulated service test solar collector; corrosion; NBSIR 81-2339.

elevators; handicapped; pressurization; smoke control; stairwells; building fires; egress; 21226.

elevators (lifts); evacuation; handicapped; pressurization; smoke control; stairwells; building fires; egress; NBSIR 82-2507.

ellipsometric; integrated circuits; aluminum-oxide interlayer; Auger; capacitance-voltage; electron devices; 20827.

ellipsometry; iron; passive films; potentiostat; anodic oxidation; dissolution of passive films; 20882.

ellipsometry; niobium; optical constants; reflectance; refractive index; dielectric constants; 21183.

ellipsometry; polysilicon films; silicon dioxide films; silicon nitride films; standard reference materials; thin films; 21107.

elliptic equations; finite elements; multi-level iterations; triangulations; adaptive meshes; eigenvalues; 20823.

elliptic partial differential equations; finite difference methods; high order accuracy; Poisson equation; 20779.

elliptic solvers; finite elements; interactive graphics; MOS transistor; NBSIR 82-2471.

elongation; exposure conditions; membrane properties; roofing membranes; single-ply roofing; tensile strength; test methods; 20841.

elongation; low temperature; maximum strength; mechanical properties; yield strength; Young's modulus; compressive strength; concrete mortar; NBSIR 82-1658.

ELS; energy loss spectroscopy; Fano effect; nickel; 21390.

embedded monitoring system; performance measurements; SP500-95; 1982 October. 191-194.

emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; NBS-GCR-82-383.

emergency egress; fire protection; fire safety; human behavior in fires; human factors; Life Safety Code; means of egress; NBSIR 82-2480.

emergency egress; fire research; human performance; modeling; pedestrian movement; regulatory process; simulation of human behavior; building codes; building fires; computer-aided design; computer simulation; 20911.

emergency response; Federal Information Processing Standards Publication; recovery actions; ADP security; backup operations; computer security; contingency planning; SP500-85.

emergency vehicle sirens; environmental tests; law enforcement; performance test methods; 20919.

emission-rate measurements; gamma-ray spectrometry; germanium-detector efficiencies; long-lived-mixed radionuclide standard; uncertainties in gamma-ray measurements; calibration of gamma-ray detector efficiencies; 20874.

emissions trading; ETIP; innovation; offsets; administrative experiment; air pollution; NBSIR 82-2475.

EMP simulator; Marx erection time; Marx generators; Remote Command Data Link; SP628; 1982 June. 316-319.

empty shell; reciprocal aid; recovery center; redundant facilities; shared contingency facility; backup operations; contingency planning; disaster recovery; SP500-95; 1982 October. 439-441.

encapsulant; integrated circuit; RTV; silicone; SP400-72; 1982 April. 275-280.

encapsulants; failure mechanisms; nucleating agent; phase change storage; service life prediction; crystal growth; NBSIR 81-2422.

encoder; law enforcement standard; selective signaling; squelch systems; tone-coding; decoder; digital controlled; 20991.

encoders; pulse; standards; waveform generation; waveform measurements; waveform recorder; converters; electromagnetics; SP634.

end user; host independent; monitor; network; performance; remote; response time; series/l; sidestreaming; simulated commands; 327X emulator; accurate data; SP500-95; 1982 October. 401-407.

energetics; excited states; kinetics; methylene; radicals; vinylidene; 20783.

energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; 21254.

energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; 21255.

energy; energy balance; energy economics; ethanol; 21050.

energy; energy levels; ionization parametric interpretation; thorium; wavelengths; actinide; 20878.

energy; enforcement; health and safety; passive design; solar energy; standards; building regulations; buildings; NBSIR 82-2554.

energy; field tests; foundation design; hammer; in-situ tests; Standard Penetration Test; boring; drilling; 20951.

energy; heat-recovery; insulation; measurement; office-building; radiant; solar; space-heating; air-cooling; air leakage; 20961.

energy; heat transfer; hot water; measurement; rating; solar; standards; testing; 21264.

energy; instrumentation; particle size; pigment; computers; 21013.

energy; liquid natural gas; coordinate transformation; custody transfer; 21324.

energy analysis; equipment performance; gas furnace; heat pump; simplified calculation; air conditioner; 21141.

energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; SP489, Supplement 1.

energy and environmental data; evaluated data; materials data; standard reference data; technical activities 1981; thermochemical and thermophysical data; data compilation; NBSIR 81-2442.

energy balance; energy economics; ethanol; energy; 21050.

energy balance; natural ventilation; psychological needs; view out; window; window management; control; daylight; 21043.

energy conservation; energy consumption; flow control valve; heat pump; stratification; test method; water heater; NBSIR 81-2372.

energy conservation; energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; TN1156.

energy conservation; equipment selection; equipment sizing; heat pump; life-cycle costs; benefit-cost analysis; NBSIR 80-2176.

energy conservation; existing buildings; rehabilitation; building accessibility; building rehabilitation guidelines; code enforcement; earthquake requirements; 21385.

energy conservation; feedback; incentives; metering; rate structures; water conservation; consumer education; NBSIR 80-2119.

energy conservation; field measurement of building energy consumption; optimal weatherization; residential energy consumption; weatherization; Community Action Agencies; Community Services Administration; costs of residential weatherization; BSS144.

energy conservation; field measurement of building energy consumption; optimal weatherization; Community Action Agencies; Community Services Administration; costs of residential



weatherization; *NBSIR 82-2539*.

energy conservation; guarded hot plate; heat flow meter; heat transfer; low-density mineral fiber; thermal conductivity; thermal resistance; thickness effect; building insulation; *NBSIR 82-2538*.

energy conservation; heat transfer in buildings; night space cooling; night ventilation; passive solar heating; building thermal mass; dynamic performance of buildings; *BSS137*.

energy conservation; housing; insulation; space heating and cooling costs; space heating and cooling requirements; architecture; building design; cost-benefit analysis; economics; *NBSIR 81-2380*.

energy conservation in lighting; general lighting; illumination energy; lighting energy; task lighting; building energy performance; building subsystem energy criteria; *21042*.

energy consumption; flow control valve; heat pump; stratification; test method; water heater; energy conservation; *NBSIR 81-2372*.

energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; *TN1156*.

energy controls; HVAC system; microprocessor control; pneumatic control system; velocity algorithm; building controls; digital-to-pneumatic conversion; direct digital control; *20995*.

energy curve; polarizabilities; Van der Waals; damped dispersion; *20788*.

energy deposition; extreme ultraviolet; high resolution; lithography; photoresists; synchrotron radiation; *21078*.

energy deposition spectra; energy distributed neutron spectra; frequency averaged energy loss; microdosimetric parameters; bin-averaged cross sections; dose-averaged energy loss; *21029*.

energy dispersion; impurities; silicon; valence states; Yukawa potential; bandgap narrowing; Bargmann potential; conduction states; donors; effective mass; *20855*.

energy dispersive diffractometry; high energy photons; residual stress; *20887*.

energy dispersive diffractometry; high energy photons; residual stress; *21350*.

energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; residual stress; stress measurements; ultrasonics; x-ray diffraction; Barkhausen noise; *20926*.

energy dispersive x-ray spectrometry; image analysis; scanning transmission; selected area electron diffraction; transmission electron microscope; electron microscope; *SP619*; 1982 March. 207-210.

energy distributed neutron spectra; frequency averaged energy loss; microdosimetric parameters; bin-averaged cross sections; dose-averaged energy loss; energy deposition spectra; *21029*.

energy economics; ethanol; energy; energy balance; *21050*.

energy economics; life-cycle costing; solar energy; building economics; commercial buildings; economic analysis; *NBSIR 82-2540*.

energy gap; superconductivity; tunneling;  $\text{AuAl}_2$ ; *21351*.

energy level; ionization energy; spark; spectrum; ultraviolet; yttrium; *21240*.

energy levels; erbium; gadolinium; neodymium; samarium; spectrum; tantalum; tungsten; ytterbium; barium; dysprosium; *20845*.

energy levels; Eu; Gd; Ho; Nd; Pr; Sm; Tb; wavelength; Ce; *20877*.

energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; *21185*.

energy levels; ionization parametric interpretation; thorium; wavelengths; actinide; energy; *20878*.

energy levels; K XIV; Sc XVI; Ti XVII; wavelengths; V XVIII; Ca XV; Cl XII; *21393*.

energy loss spectroscopy; Fano effect; nickel; ELS; *21390*.

energy management and control systems; HVAC system control; parameter estimator; PI-controller; recursive least squares algorithm; self-tuning control algorithm; adaptive control; air handling unit; direct digital control; *NBSIR 82-2591*.

energy metering; field calibration; metering accuracy CCVTs; 500 kV; 500 kV substation measurements; CCVTs; EHV revenue metering; *TN1155*.

energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; *SP631*.

energy pooling; lasers; photoelectron spectrum; superelastic collisions; associative ionization; *21221*.

energy recovery; incineration; New York City; resource recovery; solid waste management; steam production; destruct heating; electricity production; *NBS-GCR-82-409*.

energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; *TN1156*.

energy release rate; high temperature fracture;  $J$ -integral; Si-Al-O-N; singular integral equation; crack growth model; creep cavitation; diffusive crack growth; *20931*.

energy resolved emittance; energy spectrum; Thomson spectrometer; charge to mass ratio; *SP628*; 1982 June. 257-265.

energy spectrum; Thomson spectrometer; charge to mass ratio; energy resolved emittance; *SP628*; 1982 June. 257-265.

energy storage; rehydration; solar; calcium-aluminum hydrates; calorimetry; dehydration; *NBSIR 82-2531*.

energy transfer; fire tests; flame spread; ignition; mass loss; test methods; calorimeters; correlation; *NBSIR 82-2536*.

energy transfer; flames; ionization; multiphoton; optogalvanic; two photons; *21132*.

energy transfer; hydrogen halide; molecular relaxation; vibration; *JPCRD 11(3)*; 953-996; 1982.

energy transfer; intramolecular dynamics; laser-excited fluorescence; laser-induced chemistry; multiphoton processes; unimolecular reactions; vibrational relaxation; *21341*.

enforcement; health and safety; passive design; solar energy; standards; building regulations; buildings; energy; *NBSIR 82-2554*.

enforcement; inspections; NRC; radiation measurements; regulations; regulatory guides; traceability; *SP609*; 1982 February. 129-133.

engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; structural engineering; *21177*.

engineering failure mode; failure; failure analysis; failure modes and effects analysis; maintenance (inspection) interval; *SP640*; 1982 October. 45-60.

engine-generator efficiency; environmental impact; heat recovery; total energy system; absorption chillers; boiler performance; central utility plant; diesel engine performance; *NBSIR 82-2474*.

engine-generator efficiency; integrated utility system; total energy systems-economic and engineering analysis; waste heat recovery; absorption chillers; boiler performance; diesel engine performance; *NBSIR 82-2483*.

engine lubricants; lubricating oil; motor oil; petroleum oil; recycled oil; re-refined oil; test procedures; basestock; *20990*.

engine sequence tests; hot tube; laboratory bench tests; oxidation; solubilization; automotive crankcase oils; bench test procedures; catalysts; correlation; dispersancy; *21279*.

English-like; programming language; self documenting; *SP500-94*; 1982 October. 84-94.

Enskog equation; hard sphere gas; kinetic models; *20890*.

Enskog model; equation of state; hard spheres; propane; viscosity; corresponding states; *21225*.

enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; *Monogr. 170*.

enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; *Monogr. 169*.

enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; *TN1051*.

enthalpies of dilution; enthalpy; entropy; flue gas desulfurization; Gibbs energy osmotic coefficients; thermochemical tables; activity coefficients; binary aqueous systems; *NBSIR 81-2345*.

enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables; critically evaluated data; *JPCRD 11(3)*; 695-



940; 1982.

enthalpy; entropy; evaluated data; Gibbs energy; inorganic chemistry; thermochemistry; chemical thermodynamics; *JPCRD 11(Suppl. 2)*: 394 pp.; 1982.

enthalpy; entropy; evaluated data; heat capacity; thermodynamics; elements; 20819.

enthalpy; entropy; flue gas desulfurization; Gibbs energy osmotic coefficients; thermochemical tables; activity coefficients; binary aqueous systems; enthalpies of dilution; *NBSIR 81-2345*.

enthalpy; entropy; glass transition; heat capacity; linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid); *JPCRD 11(4)*: 1065-1089; 1982.

enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; *TNI048*.

enthalpy; equation of state; heavy water; Helmholtz function; PVT; specific heats; speed of sound; thermodynamic properties; vapor pressure; *JPCRD 11(1)*: 1-14; 1982.

enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene; atactic; crystal; crystallinity; density; *JPCRD 11(2)*: 313-325; 1982.

enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; conductivity; electrolytes; *NBSIR 81-2356*.

enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; 20930.

enthalpy; heat capacity; high temperature; standard reference material; synthetic sapphire; aluminum oxide; corundum; drop calorimetry; *J. Res. 87(2)*: 159-163; 1982 March-April.

enthalpy of combustion; estimation from composition; gaseous fuel mixtures; heating value; hydrocarbon gases; ideal gas; real gas; reference measurement conditions; calorific value; *NBSIR 82-2401*.

enthalpy of combustion; flow calorimetry; municipal solid waste; refuse; refuse-derived-fuel; 25 gram capacity flow calorimeter; *NBSIR 82-2457*.

enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; *JPCRD 11(1)*: 83-99; 1982.

entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; schema design; database design; database management; database modeling; database schema translation; database semantics; *NBS-GCR-82-390*.

entrainment; fire plumes; flame size; flame structure; room fires; ceilings; diffusion flames; *NBS-GCR-82-402*.

entrainment; fire plumes; flow rates; opening flows; air flows; compartment fires; *NBSIR 82-2520*.

entrainment; flame angle; openings; plume; room fire; 20810.

entrainment; heat flux; radiation; turbulence; buoyancy; cross-correlation; diffusion flames; *NBSIR 82-2473*.

entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; *TNI051*.

entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; *Monogr. 169*.

entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; *Monogr. 170*.

entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables; critically evaluated data; enthalpy; *JPCRD 11(3)*: 695-940; 1982.

entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; *JPCRD 11(1)*: 83-99; 1982.

entropy; evaluated data; Gibbs energy; inorganic chemistry; thermochemistry; chemical thermodynamics; enthalpy; *JPCRD 11(Suppl. 2)*: 394 pp.; 1982.

entropy; evaluated data; heat capacity; thermodynamics; elements; enthalpy; 20819.

entropy; flue gas desulfurization; Gibbs energy osmotic coefficients; thermochemical tables; activity coefficients; binary aqueous systems; enthalpies of dilution; enthalpy; *NBSIR 81-2345*.

entropy; glass transition; heat capacity; linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid); enthalpy; *JPCRD 11(4)*: 1065-1089; 1982.

entry control; hardware; installation; locking device classification; lock operation; characteristics; door security; *NBSIR 81-2233*.

environment; EPA Provisional Methodology; particle technologist; asbestos minerals; electron microscopical method; *SP619*; 1982 March. 183-189.

environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; speciation; arsenic; atomic absorption; 21125.

environment; human health; National Environmental Specimen Bank; specimen banking; storage evaluation and analysis; 21126.

environment; laboratory accreditation; updated information; *SP632*; 1982 March. 36-39.

environment; natural material; radioactivity; radionuclide; standard; traceability; calibration; *SP609*; 1982 February. 117-127.

environment; radioactivity; radiopharmaceuticals; standards; traceability; absorbed dose; 21355.

environment; software development and maintenance; software validation; standards; verification and testing; V,V&T technique and tools; *NBSIR 82-2482*.

environmental; intercomparison; standards; thermoluminescence; calibration; dosimetry; *SP609*; 1982 February. 111-116.

environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; units; data reporting; detection limit; 20888.

environmental conditions; indoor testing; modeling; NBS; solar; solar domestic hot water system; stratification; test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; *BSS140*.

environmental impact; heat recovery; total energy system; absorption chillers; boiler performance; central utility plant; diesel engine performance; engine-generator efficiency; *NBSIR 82-2474*.

environmental measurements; international quality assurance; national quality assurance; natural-matrix reference materials; radioactivity measurements; radiopharmaceuticals; traceability; 20883.

environmental measurements; radon; radon daughters; *SP609*; 1982 February. 135-143.

Environmental Policy Institute; water conservation; conservation laws; *SP624*; 1982 June. 61-66.

environmental samples; ultratrace analysis; x-ray spectrometry; cation exchange resin-loaded filters; 21364.

environmental tests; law enforcement; performance test methods; emergency vehicle sirens; 20919.

enzymatic assay; gas chromatography/mass spectrometry; leachables; mammary prosthesis; polymeric implants; prolyl hydroxylase; *NBSIR 81-2436*.

enzymatic digestion; high-performance liquid chromatography; peptides; amino acid analysis; anion-exchange; cytochrome c; 21293.

enzymes; protein structure; ribonuclease; x-ray diffraction; active site; charge relay; 20893.

Eötvös experiment; fibers; general relativity; gravitation; null experiments; relativity; 20954.

EPA-NBS agreement; methodology manual; standardized measurement protocol; airborne asbestos fibers; electron microscopic analysis; *SP619*; 1982 March. 1-4.

EPA provisional method; fibers; sampling errors; ambient air; asbestos; *SP619*; 1982 March. 154-161.

EPA provisional method; filter; asbestos; asbestos minerals; chrysotile fiber; *SP619*; 1982 March. 190-206.

EPA Provisional Methodology; particle technologist; asbestos minerals; electron microscopical method; environment; *SP619*; 1982 March. 183-189.

epicyclic system; gear train; planet bearings; planetary gears; bearing life; bearings; *SP640*; 1982 October. 130-149.

EPT-76; germanium resistance thermometers; IPTS-68; magnetic thermometers; NQR thermometers; rhodium-iron thermometers;



thermistors; 20933.

equation; flow; horizontal; motion; partially-filled pipe; slope; solid; stream-depth; surge; transport; velocity; water; *NBSIR 81-2450*.

equation of state; ethylene; helium; saturation density; vapor phase; virial coefficients; Burnett method; 21228.

equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; enthalpy; *TN1048*.

equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients; 21208.

equation of state; expansivity; Pitzer's equations; *PVT*; volume; volumetric properties; apparent molal volume; aqueous sodium chloride solutions; compressibility; density; *JPCRD 11(1)*: 15-81; 1982.

equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; *TN1051*.

equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; *Monogr. 169*.

equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; *Monogr. 170*.

equation of state; hard spheres; propane; viscosity; corresponding states; Enskog model; 21225.

equation of state; heavy water; Helmholtz function; *PVT*; specific heats; speed of sound; thermodynamic properties; vapor pressure; enthalpy; *JPCRD 11(1)*: 1-14; 1982.

equations of state; heat of mixing; liquid density; mixtures; second virial coefficients; vapor-liquid equilibrium; vapor pressure; volume change of mixing; *JPCRD 11(3)*: 941-951; 1982.

equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables; critically evaluated data; enthalpy; entropy; *JPCRD 11(3)*: 695-940; 1982.

equilibrium jog array; Mode I brittle crack; activation energy for double kink formation; boundary conditions for atomic simulations; brittle crack growth rate; double kink nucleation; edge dislocation pileup; 21193.

equilibrium theory; glass formation; glass transition; polymer glasses; 21067.

equipment design failures; marine environmental factors; moisture intrusion in avionics equipment; avionics component design; avionics corrosion damage; corrosion damage; *SP640*; 1982 October. 379-399.

equipment performance; gas furnace; heat pump; simplified calculation; air conditioner; energy analysis; 21141.

equipment research; fire research; geotechnical research; illumination; structural research; thermal performance; building research; 20896.

equipment selection; equipment sizing; heat pump; life-cycle costs; benefit-cost analysis; energy conservation; *NBSIR 80-2176*.

equipment sizing; heat pump; life-cycle costs; benefit-cost analysis; energy conservation; equipment selection; *NBSIR 80-2176*.

equipment standards; law enforcement; mobile digital terminals; voice message traffic; digital communications equipment; digital techniques; *NBS-GCR-81-356*.

equivalence principle; field distribution; slot; aperture; cavity; *NBSIR 82-1659*.

ERA model; information resource management; software; computer program; database; database management system; data dictionary system; data management; data standards; *NBS-GCR-82-384*.

ERA model; information resource management; software; computer program; database; database management system; data dictionary system; data management; data standards; *NBS-GCR-82-386*.

erbium; gadolinium; neodymium; samarium; spectrum; tantalum; tungsten; ytterbium; barium; dysprosium; energy levels; 20845.

erosion; flame spray process; plasma coatings; thermal deposition systems; thermospray process; wear; aluminum non-skid coating; corrosion control; *SP640*; 1982 October. 194-196.

erosion; materials properties; mechanical properties; physical properties; refractories; alloys; coal conversion; coal gasification; corrosion; *SP642*.

ErRh<sub>4</sub>B<sub>4</sub>; ferromagnetic superconductors; neutron scattering; ternary superconductors; antiferromagnetic superconductors; chevre-phase; 21131.

error; fibrils; laboratories; asbestos analysis; electron microscope; *SP619*; 1982 March. 162-168.

error caused by response time; impulse measurements; numerical correction; analog-to-digital converters; *SP628*; 1982 June. 341-354.

error distributions; Gaussian assumptions; membrane filter method; statistical considerations; airborne asbestos; *SP619*; 1982 March. 145-153.

error propagation; matrix inversion; physical property; elastic constants; 20818.

errors; pulse measurements; time domain measurements; waveform measurements; waveform recorders; *SP634*; 1982 June. 1-5.

errors; pulse pileup; accuracy; activation analysis; count rate effects; dead time; 21249.

errors in variable; functional; large sample, convex; regression; statistical methods; structural; *J. Res. 87(1)*: 67-70; 1982 January-February.

error sources; high voltage measurements; revenue metering; calibration; CCVT; EHV substations; *NBSIR 81-2360*.

ESCA (electron spectroscopy for surface analysis); ion-scattering spectroscopy; secondary-ion mass spectroscopy; surface analysis; x-ray photoelectron spectroscopy; Auger-electron spectroscopy; 21382.

escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; *NBS-GCR-82-383*.

escape; fatalities; fire; flaming; flashover; nonresidential; residential; scenario; smoldering; cigarettes; codes; 20775.

ESD; ion kinetic energy distribution; methanol; methanol-d<sub>1</sub>; methanol-d<sub>3</sub>; deuterium; electron stimulated desorption; 21133.

ESD; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; 20832.

ESDIAD; low energy electron diffraction; thermal desorption; adsorption; carbon monoxide on Ni(111); electron stimulated desorption; 21100.

ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosaniline; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; 20905.

estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; *SP631*.

estimation; heats of formation; procedure; chlorinated benzenes; chlorinated dioxins; chlorinated phenols; 21346.

estimation from composition; gaseous fuel mixtures; heating value; hydrocarbon gases; ideal gas; real gas; reference measurement conditions; calorific value; enthalpy of combustion; *NBSIR 82-2401*.

ethane; ethane-d<sub>6</sub>; ethynyl radicals; rate constants; abstraction; 20780.

ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; *JPCRD 11(1)*: 83-99; 1982.

ethane; ground state constants; infrared spectrum; low temperature spectrum; torsional splittings; C-H stretching region; difference-frequency laser; Doppler-limited resolution; *J. Res. 87(3)*: 237-256; 1982 May-June.

ethane-d<sub>6</sub>; ethynyl radicals; rate constants; abstraction; ethane; 20780.

ethanol; energy; energy balance; energy economics; 21050.

ethanol; intensities; interstellar molecules; microwave spectra; molecular constants; propionitrile; radio astronomy; rotational spectrum; *JPCRD 11(2)*: 251-312; 1982.

ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; radiochromic dye; alanine; biographic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; 20889.

Ethernet; Ethernet performance; Ethernet simulation; higher level protocols; interactive program development; layered architecture; time-sharing; user level workloads; *SP500-95*; 1982 October. 375-388.

Ethernet; local; microprocessor; network; serial; broadcast; coaxial; communication; contention; data; digital; 20839.

Ethernet performance; Ethernet simulation; higher level protocols;



interactive program development; layered architecture; time-sharing; user level workloads; Ethernet; *SP500-95*; 1982 October. 375-388.

Ethernet simulation; higher level protocols; interactive program development; layered architecture; time-sharing; user level workloads; Ethernet; Ethernet performance; *SP500-95*; 1982 October. 375-388.

ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; *JPCRD 11(1)*: 83-99; 1982.

ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties; argon; critically evaluated data; density; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

ethylene; heat capacity; saturated liquid; specific heat; thermodynamic properties; coexistence; 21187.

ethylene; helium; saturation density; vapor phase; virial coefficients; Burnett method; equation of state; 21228.

ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; enthalpy; equation of state; *TN1048*.

ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients; equation of state; 21208.

ethylene vinyl acetate; initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon; crosslinking; dosimetry; 20900.

ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; diffusion; *NBSIR 81-2314*.

ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; oligomers; polyethylene; polypropylene; radiotracer; antioxidants; diffusion; *NBSIR 82-2472*.

ethynyl; radicals; abstraction reactions; activation energies; bond-energy-bond-order; CN; 20781.

ethynyl radicals; rate constants; abstraction; ethane; ethane- $d_6$ ; 20780.

ETIP; innovation; offsets; administrative experiment; air pollution; emissions trading; *NBSIR 82-2475*.

Eu; Gd; Ho; Nd; Pr; Sm; Tb; wavelength; Ce; energy levels; 20877.

eutectic solidification; metallic glasses; palladium-copper-silicon alloys; rapid solidification; amorphous alloys; coupled growth; 21190.

evacuation; fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; escape; *NBS-GCR-82-383*.

evacuation; fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; sprinkler systems; bibliographies; *NBSIR 81-2438*.

evacuation; fire emergency planning; fire protection; group homes; mental disorders; board and care homes; developmentally disabled; elderly persons; *NBS-GCR-82-408*.

evacuation; handicapped; pressurization; smoke control; stairwells; building fires; egress; elevators (lifts); *NBSIR 82-2507*.

evaluated data; Gibbs energy; inorganic chemistry; thermochemistry; chemical thermodynamics; enthalpy; entropy; *JPCRD 11(Suppl. 2)*: 394 pp.; 1982.

evaluated data; heat capacity; thermodynamics; elements; enthalpy; entropy; 20819.

evaluated data; materials data; standard reference data; technical activities 1981; thermochemical and thermophysical data; data compilation; energy and environmental data; *NBSIR 81-2442*.

evaluation; Federal R&D; industry; innovation; State and local governments; technology transfer; technology utilization; 20854.

evaluation; in-place testing; inspection; nondestructive testing; quality assurance; building materials; concrete; *J. Res. 87(5)*: 407-438; 1982 September-October.

evaluation; International Electrotechnical Commission; laboratory; test facilities; certifiers; *SP632*; 1982 March. 74-75.

evaluation criteria; Federal agencies; language translators; portability; program inventory; RFP; statement of work; acceptance tests; conversion contracting; conversion problems; deliverables; *SP500-90*.

evaluation of system life costs; teleprocessing services procurements; unbalanced pricing; workload forecasting; basic agreement solicitations; *SP500-95*; 1982 October. 27-33.

evaluation procedures; excess enthalpy; heat of mixing; benzene; cyclohexane; *JPCRD 11(4)*: 1129-1151; 1982.

evaluation procedures; excess Gibbs function; vapor-liquid equilibrium; activity coefficients; benzene; cyclohexane; *JPCRD 11(4)*: 1099-1127; 1982.

evaluation procedures; excess volume; volume change of mixing; benzene; cyclohexane; *JPCRD 11(4)*: 1153-1171; 1982.

evaluation process; hot water; passive solar; performance criteria; solar energy; thermal performance; active solar; *NBS-GCR-82-397*.

examination; planar; stationary; unshielded; chronoamperometry; coefficient; diffusion; electrodes; 21361.

excess enthalpy; heat of mixing; benzene; cyclohexane; evaluation procedures; *JPCRD 11(4)*: 1129-1151; 1982.

excess Gibbs energy; isopiestic; nickel nitrate; osmotic coefficient; solubility; solutions; thermodynamics; activity coefficient; electrolyte; 21234.

excess Gibbs energy; isopiestic; osmotic coefficient; potassium carbonate; solubility; solutions; thermodynamics; activity coefficient; electrolytes; 21233.

excess Gibbs energy; osmotic coefficient; solutions; thermodynamic properties; activity coefficient; critical evaluation; electrolyte; 20936.

excess Gibbs function; vapor-liquid equilibrium; activity coefficients; benzene; cyclohexane; evaluation procedures; *JPCRD 11(4)*: 1099-1127; 1982.

excess volume; volume change of mixing; benzene; cyclohexane; evaluation procedures; *JPCRD 11(4)*: 1153-1171; 1982.

exchange interaction; spin detector; spin-orbit interaction; spin polarization; amorphous ferromagnet; 21087.

excimer; rare-gas halide; transition moments; blue-green laser; effective core potentials; 21309.

excimer laser; free-bond absorption; gain cross section; alkali dimers; 21322.

excimer lasers; fluorescence branching ratios; kinetics; rare gas halides; rate coefficients; 21299.

excitation; Ga II; resonance line; absolute cross section; crossed beams; electron-ion collisions; 21317.

excitation; measurement; x-ray emission lines; x-ray photoelectron spectra; crystal spectroscopy; electrons; 21330.

excitation; nitrogen; numerical calculation; transport; diffusion; drift velocity; electrons; 21002.

excitation; sodium; 2s; continuum; double electron; 21331.

excitation-autoionization;  $Ga^+$ ; ionization;  $Zn^+$ ; crossed beams; electron impact; 21071.

excitation-autoionization; ionization;  $Mg^+$ ; Na iso-sequence;  $Si^{+3}$ ;  $Al^{+2}$ ; crossed beams; cross sections; electron impact; 21073.

excited states; kinetics; methylene; radicals; vinylidene; energetics; 20783.

excited state spectrum; saturation spectrum; atomic mercury; degenerate four-wave mixing; 20983.

existing buildings; rehabilitation; building accessibility; building rehabilitation guidelines; code enforcement; earthquake requirements; energy conservation; 21385.

expansion; alloy; amalgam; dental; dimensional change; 21156.

expansion; hardening shrinkage; hygroscopic expansion; polymerization; water sorption; absorption; composite resins; 21052.

expansivity; Pitzer's equations; *PVT*; volume; volumetric properties; apparent molal volume; aqueous sodium chloride solutions; compressibility; density; equation of state; *JPCRD 11(1)*: 15-81; 1982.

experiment; forward scattering; quenching; resonance; sodium; transport; backscattering; 20953.

experimental; inelastic scattering;  $O_2$ ; Rydberg series; angular distributions;  $c^4\Sigma_u$  limit; electrons; 21077.

experimental melting curves; high pressure; high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; *JPCRD 11(4)*: 1005-1064; 1982.

Experimental Technology Incentives Program; innovation; productivity analysis; computerized analysis; electric utility rate regulation; *NBSIR 80-2046*.

experimental/theoretical comparisons; precision x-ray energies; 21109.

expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; research; state-of-the-art; applications; artificial intelligence; *NBSIR 82-2505*.



expert systems; knowledge-based systems; knowledge engineering; knowledge representation; problem solving; process planning; AMRF; artificial intelligence; automated manufacturing; *NBSIR 81-2466*.

exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; *SP631*.

exporting; governmental regulations; manufacturer; tractor model; *SP632*; 1982 March. 59-60.

exposure; nonionizing; radiation; radiofrequency; regulation; safety; standards; bioeffects; dosimetry; electromagnetic; *21038*.

exposure conditions; membrane properties; roofing membranes; single-ply roofing; tensile strength; test methods; elongation; *20841*.

exposure tests; marine environments; salt fog; alternate immersion; corrosivity monitoring device; *SP640*; 1982 October. 476-494.

external aerodynamics; fluid dynamics; mathematical modeling; numerical methods; unsteady flow; vortex shedding; computer simulation; *21044*.

external test driver; performance evaluation; remote terminal emulation; system design; teleprocessing systems; testing; *SP500-95*; 1982 October. 415-421.

extraction; food packaging; heat stabilizers; migration; octylins; poly(vinyl chloride); diffusion; *21325*.

extrapolation chamber; free-air chamber; ionizing radiation; measurement standards; radiation dosimetry; standards; calorimeter; cavity ionization chamber; *SP609*; 1982 February. 29-30.

extreme pressure and antiwear properties; greases; solid lubricant additive; abrasive wear; antimony thioantimonate; *SP640*; 1982 October. 150-161.

Extreme Type II; hurricanes; Weibull; windspeeds; *21211*.

extreme ultraviolet; high resolution; lithography; photoresists; synchrotron radiation; energy deposition; *21078*.

extreme winds; fluid mechanics; meteorology; structural engineering; wind; climatology; *21212*.

## F

fabric flammability; fire models; fire tests; home fires; hospitals; mattresses; nursing homes; room fires; smoldering; *NBSIR 81-2440*.

fabric flammability; fire research; fire tests; flame research; smoke; bibliographies; building fires; coal mines; combustion products; compartment fires; *NBSIR 82-2499*.

fabrics; flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; textiles; upholstered furniture; cigarettes; *21128*.

facilitated transport; liquid membrane; membrane; purification; separation; chemical engineering; *21241*.

facility design; future plans; implementation; objectives; purpose; *SP609*; 1982 February. 77-79.

fading; measurement of lamp output; plastic plate; quinoline dye; solar energy; *20798*.

FADPUG; software engineering; system decomposition; top-down; documentation; documentation standards; *SP500-94*; 1982 October. 166-171.

failure; failure analysis; failure modes and effects analysis; maintenance (inspection) interval; engineering failure mode; *SP640*; 1982 October. 45-60.

failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; *SP621*.

failure; fatigue; fracture; fracture surface; fracture toughness; analysis; bridges; crack propagation; *SP621*; 1982 October. 95-109.

failure; fatigue; rapid transit; steel frames; welding; brittle fracture; *SP621*; 1982 October. 110-129.

failure; flat plate; shear; strength; building; collapse; concrete; concrete strength; construction; *BSS145*.

failure; fracture mechanics; girth welds; pipeline; plasticity; strength; stress; toughness; collapse; cracks; defects; *21169*.

failure; hybrid microcircuit; moisture; nichrome resistors; semiconductor devices; dew point; *SP400-72*; 1982 April. 175-177.

failure; hyperbolic shell; shell; collapse; concrete; concrete strength; construction; cooling tower; *BSS148*.

failure; steel; walkway; building; collapse; connection; construction; *BSS143*.

failure analysis; failure modes and effects analysis; maintenance

(inspection) interval; engineering failure mode; failure; *SP640*; 1982 October. 45-60.

failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve; database; data collection; *21176*.

failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; *SP621*.

failure investigation; falsework; field load tests; formwork; post-tensioning; structural analysis; bridge; collapse; concrete; construction; *NBSIR 82-2593*.

failure mechanisms; nucleating agent; phase change storage; service life prediction; crystal growth; encapsulants; *NBSIR 81-2422*.

failure modes; hybrid manufacturing; moisture sources; adsorption; corrosion; dew point; *SP400-72*; 1982 April. 117-125.

failure modes and effects analysis; maintenance (inspection) interval; engineering failure mode; failure; failure analysis; *SP640*; 1982 October. 45-60.

Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; *SP640*; 1982 October. 235-254.

failure prevention; ferro-magnetic alloys; inspection; metal distress; metal parts; NDE; nickel base alloys; testing; defect detection; eddy current; *SP640*; 1982 October. 454.

failure prevention; human performance; material and material processing; mechanical and structural failure; operational environment; preventive maintenance; wear; corrosion; *SP640*; 1982 October. 2-16.

failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; large scale models; mathematical model; pullout test; stress contours; concrete; crack propagation; *NBSIR 82-2484*.

failure theory; finite element method; internal strain; laboratory testing; large scale models; mathematical model; pullout test; stress contours; concrete; crack propagation; failure surface geometry; *NBSIR 82-2484*.

falsework; field load tests; formwork; post-tensioning; structural analysis; bridge; collapse; concrete; construction; failure investigation; *NBSIR 82-2593*.

Fano effect; nickel; ELS; energy loss spectroscopy; *21390*.

Faraday constant; fundamental constants; silver; silver coulometer; atomic weight; atomic weight of silver; coulometer; electrochemical equivalent; *J. Res. 87(1)*: 21-22; 1982 January-February.

Faraday constant; isotopic abundance; mass spectrometry; silica gel; silver; silver iodide; absolute ratios; atomic weight; *J. Res. 87(1)*: 9-19; 1982 January-February.

Faraday effect; pulsed electric currents; *SP628*; 1982 June. 277-288.

far infrared; hyperfine constants; lambda doubling; laser magnetic resonance; rotational levels; Zeeman effect; CH; *21273*.

far infrared absorption; induced dipole; line shape; rare gas mixtures; spectra; transient dipoles; collision-induced absorption; collision-induced light scattering; *21173*.

far infrared spectra; hydrogen; hydrogen mixtures; rotational transitions; spectra; absorption coefficient; collision-induced; *21165*.

far ultraviolet radiation; grating; monochromator; synchrotron radiation; toroidal grating monochromator; vacuum ultraviolet monochromator; *21079*.

Fast Fourier Transforms; high speed transient digitizers; pulsed power generators; cable attenuation; *SP628*; 1982 June. 381-391.

fast Fourier transforms; sampling-rate drift; deconvolution; digital sampling; *SP634*; 1982 June. 47-53.

fast transport coefficients; Kubo-Green relation; nonequilibrium dynamics; vortex viscosity; *21238*.

fatalities; fire; flaming; flashover; nonresidential; residential; scenario; smoldering; cigarettes; codes; escape; *20775*.

fatalities; fire; heart disease; heavy metals; hydrogen chloride; scenario; alcohol; carbon monoxide; cigarettes; *20858*.

fatalities; hydrogen cyanide; polymer; toxicity; autopsy; biological; carboxyhemoglobin; *20811*.

fatigue; fracture; fracture surface; fracture toughness; analysis; bridges; crack propagation; failure; *SP621*; 1982 October. 95-109.

fatigue; fractures; machines; stress systems; tension loading; brittle



materials; ductile materials; *SP621*; 1982 October. 196-200.

fatigue; freight car truck; railroad accidents; railroad freight car; railroad testing; reliability; derailments; *SP621*; 1982 October. 3-17.

fatigue; guys; mechanical testing; nondestructive testing; pultrusions; standards; composite materials; damage; *21195*.

fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; residual stress; standards; stress measurement; terminology; ultrasonics; x-ray diffraction; *21344*.

fatigue; microstructures; titanium; alloys; anodic polarization; corrosion; *21174*.

fatigue; morphology; polyethylene; stress-crack resistance; stress-relaxation; ultra high molecular weight; creep; *NBSIR 82-2493*.

fatigue; rapid transit; steel frames; welding; brittle fracture; failure; *SP621*; 1982 October. 110-129.

fatigue; stability; storage coil; superconductor; useful life; cable assembly; *21214*.

fatigue crack growth rates; fracture analysis; mechanical testing; microstructure; rail vehicles; SEM fractography; cast steels; *SP621*; 1982 October. 33-45.

F-atom reactions; infrared spectrum; matrix isolation; phenyl; photodecomposition; 1-fluorocyclohexadienyl; benzene; *20917*.

faucet aerators; flow reduction; groundwater law; public awareness; toilet dams; wastewater flow reduction; water conservation; *SP624*; 1982 June. 151-154.

faucet aerators; irrigation conservation; landscaping alternatives; water conservation; water-conserving devices; *SP624*; 1982 June. 53-59.

Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); *SP640*; 1982 October. 235-254.

fault detection/location system; lubrication; maintenance; maintenance management; maintenance technology; manpower utilization; reliability assessment; *SP640*.

fault isolation diagnostics; functional subsystem; line replaceable units; malfunction; microprocessor controlled test set; symptom; test strategy; automated test equipment; *SP640*; 1982 October. 223-234.

faults; jet engines; monitoring; overhaul; productivity; vibration; balancing; diagnostics; *SP640*; 1982 October. 115-129.

Fe; iron; iron energy levels; atomic energy levels; atomic spectra; *JPCRD 11(1)*: 135-241; 1982.

feature analysis; guidelines; local area networks; local network specification; requirements analysis; *SP500-96*.

Federal ADP procurement; life cycle management; long-range planning; systems planning and control; ADP planning; *SP500-95*; 1982 October. 11-18.

Federal agencies; language translators; portability; program inventory; RFP; statement of work; acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; *SP500-90*.

Federal Government computers; Federal minicomputers; Federal statistics; general purpose computers; magnetic tape units; terminals; disk units; *SP500-97*.

Federal Information Processing Standard; graphic shapes; magnetic ink characters; MICR; MICR Read Optically; OCR; optical character recognition; character shapes; data entry; *FIPS PUB 32-1*.

Federal Information Processing Standard; information processing systems; magnetic tape cassettes; magnetic tape recording; magnetic tape transports; standards; communications; computers; data interchange; *FIPS PUB 91*.

Federal Information Processing Standard; information processing systems; magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; standards; communications; computers; data interchange; *FIPS PUB 93*.

Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); channel level power control interface; computer peripherals; computers; *FIPS PUB 61-1*.

Federal Information Processing Standards; International Organization for Standardization; local area networks; National Bureau of Standards; network protocols; standards; computer networks; *21363*.

Federal Information Processing Standards (FIPS); operations phase; automated data systems; computer programs; documentation; *SP500-94*; 1982 October. 68-75.

Federal Information Processing Standards Publication; recovery actions; ADP security; backup operations; computer security; contingency planning; emergency response; *SP500-85*.

Federal Life-Cycle Cost Rules; life-cycle cost analysis; net savings; solar energy computer program; solar energy economics; solar energy systems; computer simulation models; *NBSIR 81-2379*.

Federal minicomputers; Federal statistics; general purpose computers; magnetic tape units; terminals; disk units; Federal Government computers; *SP500-97*.

Federal R&D; industry; innovation; State and local governments; technology transfer; technology utilization; evaluation; *20854*.

Federal statistics; general purpose computers; magnetic tape units; terminals; disk units; Federal Government computers; Federal minicomputers; *SP500-97*.

federal water policy; conservation management; *SP624*; 1982 June. 409-412.

Federal Water Resource Agency; water conservation; water planning; *SP624*; 1982 June. 373-378.

feedback; incentives; metering; rate structures; water conservation; consumer education; energy conservation; *NBSIR 80-2119*.

feedback control; fluid density; hydrostatic weighing; magnetic suspension; capacitance sensing; electronic balance; *21207*.

Fermi gas model; Feynman diagrams; meson exchange current; nucleus; photon; pion; electron; *21345*.

Fermi gas model; nuclear response function; nuclei; nucleons; quasi-free; charge magnetization; Coulomb sum rule; electron scattering; *21400*.

Fermion masses; internal spaces; mixing angles; neutrino oscillations; potentials; scaling; *21168*.

ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; transfer standard; absolute calibration; absolute quantum yield; actimetry; amplitude stabilized lasers; electrically calibrated radiometers; *21045*.

ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; *21392*.

ferroelectric; piezoelectric; polarization distribution; poling study; polyvinyl fluoride; pyroelectric; *21245*.

ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion; chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; *21395*.

ferrography; health monitoring; tribology; wear; wear debris analysis; diagnostics; *SP640*; 1982 October. 466-475.

ferro-magnetic alloys; inspection; metal distress; metal parts; NDE; nickel base alloys; testing; defect detection; eddy current; failure prevention; *SP640*; 1982 October. 454.

ferromagnetic glass; scanning electron microscopy; secondary electron emission; spin analyzer; spin polarized secondary electron; electron spin polarization; *21360*.

ferromagnetic superconductors; neutron scattering; ternary superconductors; antiferromagnetic superconductors; chevre-l-phase;  $\text{ErRh}_2\text{B}_4$ ; *21131*.

ferromagnetism; magnetization; neutron diffraction; spin waves; transition metals; amorphous materials; *20945*.

ferromagnetism; manganese compounds; neutron diffraction; profile refinement; rare earths; crystal fields; *20944*.

ferromagnetism; rare earths; scandium alloys; spin glass; antiferromagnetism; critical fields; *21129*.

ferrous metals; glass; nonferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles; directory; *NBS-GCR-82-366*.

ferrous scrap; iron; municipal solid waste; recycling; resource recovery; standards; steel; *21358*.

ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; survey; teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; *SP609*; 1982 February. 89-97.

Feshbach resonances; free-free transitions; Nd laser; photon-assisted transitions; angular distributions; close-coupling approximation;  $\text{CO}_2$  laser; elastic and inelastic; electron-hydrogen scattering; *20787*.

Feynman diagrams; meson exchange current; nucleus; photon; pion; electron; Fermi gas model; *21345*.

fiber; glass; mass concentrations; water samples; chrysotile asbestos; *SP619*; 1982 March. 121-131.

fiber concentrations; standard samples; asbestos fiber; biological samples; electron microscope; *SP619*; 1982 March. 53-67.

fiber counts; sample preparation; asbestos identification; asbestos



standard; electron microscopy; *SP619*; 1982 March. 138-144.

fiber identification criteria; interlaboratory calibration; preparation techniques; aqueous standard fiber dispersions; asbestos analysis variability; *SP619*; 1982 March. 91-107.

fiber loading; filters; ultrasonic baths; asbestos fiber; asbestos reference suspension; *SP619*; 1982 March. 68-76.

fiber optic joints; fiber optics; fiber optics-single mode; index profile; measurements; attenuation; bandwidth; *SP641*.

fiber optics; fiber optics-single mode; index profile; measurements; attenuation; bandwidth; fiber optic joints; *SP641*.

fiber optics; Marx generators; Remote Command Data Link; electromagnetic pulse; *SP628*; 1982 June. 310-315.

fiber optics; optical communications; optical waveguides; *H140*.

fiber optics-single mode; index profile; measurements; attenuation; bandwidth; fiber optic joints; fiber optics; *SP641*.

fiber-reinforced composites; particulate composites; wave propagation; composites; elastic constants; elastic-wave scattering; *20884*.

fibers; general relativity; gravitation; null experiments; relativity; Eötvös experiment; *20954*.

fibers; glass; physical dimensions; analytical standards; asbestos standards; chemical composition; *SP619*; 1982 March. 21-28.

fibers; sampling errors; ambient air; asbestos; EPA provisional method; *SP619*; 1982 March. 154-161.

fibre optics; gamma-ray dosimetry; leuko cyanides; neutron dosimetry; optical waveguides; radiochromic dyes; anomalous dispersion; dimethyl sulfoxide; dosimetry; *20804*.

fibrils; laboratories; asbestos analysis; electron microscope; error; *SP619*; 1982 March. 162-168.

fibrous minerals; asbestos standards; asbestos statistics; electron microscopy; *SP619*.

field and slash burning; Portland aerosol characterization study; radiocarbon; residential wood burning; urban particulates; vegetative burning; air pollution; biogenic/fossil carbon impact; *20964*.

field calibration; high accuracy; modular capacitive divider; portable system; truck-mounted; CCVT; compact; *21287*.

field calibration; metering accuracy CCVTs; 500 kV; 500 kV substation measurements; CCVTs; EHV revenue metering; energy metering; *TN1155*.

field data acquisition; field instrumentation; field performance of heat pumps; heat pumps; heat pump test methods; microcomputer; analog signal conditioning; data acquisition system; *NBSIR 81-2285*.

field distribution; slot; aperture; cavity; equivalence principle; *NBSIR 82-1659*.

field enhancement; molecular fluorescence; surface geometry; surface spectroscopy; *21031*.

field instrumentation; field performance of heat pumps; heat pumps; heat pump test methods; microcomputer; analog signal conditioning; data acquisition system; field data acquisition; *NBSIR 81-2285*.

field instruments; national radiation standards; radiation therapy; calibration; *SP609*; 1982 February. 81-88.

field intensity meter; isotropic antenna; radio frequency radiation; electromagnetic field; *20885*.

field jumps; Lorentz transformation; special relativity; surface charge conservation; transient propagation; arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; *21327*.

field load tests; formwork; post-tensioning; structural analysis; bridge; collapse; concrete; construction; failure investigation; falsework; *NBSIR 82-2593*.

field measurement; Health Physics Society; neutrons; photons; standard; testing program; conversion factors; dose equivalent; *20813*.

field measurement of building energy consumption; optimal weatherization; Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; *NBSIR 82-2539*.

field measurement of building energy consumption; optimal weatherization; residential energy consumption; weatherization; Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; *BSS144*.

field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; energy related data; *TN1156*.

field performance of heat pumps; heat pumps; heat pump test methods; microcomputer; analog signal conditioning; data acquisition system; field data acquisition; field instrumentation; *NBSIR 81-2285*.

field testing; flood forces; foundations; load capacity; mobile homes; soil anchors; soil mechanics; stiffness; wind forces; anchors; cyclic loading; *BSS142*.

field tests; foundation design; hammer; in-situ tests; Standard Penetration Test; boring; drilling; energy; *20951*.

filament micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; *SP400-74*.

fillers; acid etch; BIS-GMA; bonding; composites; dental resins; *20847*.

fillers; pedodontics; acid etch; adhesive bonding; composites; dental resins; *20915*.

film dosimetry; gamma rays; humidity effects; leucocyanines; pulse radiolysis; radiation processing; radiochromic dyes; bleaching of dyes; dose rate; dosimetry; dyes; *20844*.

film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; *21326*.

filter; asbestos; asbestos minerals; chrysotile fiber; EPA provisional method; *SP619*; 1982 March. 190-206.

filter; isooctane; liquid separation; chrysotile asbestos; electron microscopy; *SP619*; 1982 March. 85-90.

filter; monopole; tracking; tuneable; active; antenna; *20892*.

filter homogeneity; Poisson statistical process; statistical methods; analysis; asbestos fibers; chrysotile filter; *SP619*; 1982 March. 169-182.

filter loading; aerosolized fibers; airborne asbestos; analytical methods; contamination; *SP619*; 1982 March. 77-84.

filters; ultrasonic baths; asbestos fiber; asbestos reference suspension; fiber loading; *SP619*; 1982 March. 68-76.

filtration; gearboxes; helicopter transmission; pitting; rolling element bearings; rolling fatigue; spalling; *SP640*; 1982 October. 326-347.

finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; exploration; *SP631*.

fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; *SP640*; 1982 October. 257-274.

fine leak test; gross leak test; helium; hermeticity; tracer gas; bombing; *SP400-72*; 1982 April. 281-288.

fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; *SP640*; 1982 October. 257-274.

fine-structure constant; Hall effect; Landau levels; resistance standard; silicon MOSFETs; two-dimensional electron gas; *21220*.

fine structure transitions; Hund's coupling; WKB approximation; adiabatic electronic-rotational states; atomic scattering; distorted wave approximation; *20786*.

fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; speciation; arsenic; atomic absorption; environment; *21125*.

finished dimensions; improper drilling; time-domain analysis; tool failure; tool wear; vibration signatures; automated manufacturing; drill failure prediction; drill wear; *20795*.

finite collision time effects; atom pairs; binary-collision approximation; bound state effects; *20833*.

finite difference approximation; heat transfer; natural convection; nonlinear convection; numerical integration; transient fluid motion; transient heat transfer; compressible fluid motion; convection; *NBSIR 82-1660*.

finite difference computations; fire-enclosure; fluid flow; Lanczos smoothing; partial differential equations; stream function; vorticity; buoyant convection; *J. Res. 87(2)*: 165-185; 1982 March-April.



finite difference methods; high order accuracy; Poisson equation; elliptic partial differential equations; 20779.

finite element; germanium; heavily doped semiconductors; impurity levels; silicon; anisotropic Yukawa potential; 20830.

finite element; heavily doped semiconductors; impurity levels; silicon; 20851.

finite element analysis; fitness-for-service; fracture mechanics; J-integral; crack opening displacement; 21194.

finite element method; internal strain; laboratory testing; large scale models; mathematical model; pullout test; stress contours; concrete; crack propagation; failure surface geometry; failure theory; *NBSIR 82-2484*.

finite element method; nondestructive evaluation; scattering; ultrasonic waves; variational method; acoustic waves; cracks; 21229.

finite elements; interactive graphics; MOS transistor; elliptic solvers; *NBSIR 82-2471*.

finite elements; multi-level iterations; triangulations; adaptive meshes; eigenvalues; elliptic equations; 20823.

FIPS; guidelines; program documentation; software documentation; standards; documentation; *SP500-94*.

FIPS 30; format structure; machine-readable cataloging; machine-readable data files; MARC; MRDF; numeric data files; software summary; ANSI Z39.2; bibliographic control; *SP500-94*; 1982 October. 189-196.

fire; firesetters; motives; psychiatry; psychopathic personality; psychopathology; arson; behavior disorder; 21335.

fire; flaming; flashover; nonresidential; residential; scenario; smoldering; cigarettes; codes; escape; fatalities; 20775.

fire; heart disease; heavy metals; hydrogen chloride; scenario; alcohol; carbon monoxide; cigarettes; fatalities; 20858.

fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; transactions; annual reports; diffusion in metals; *NBSIR 82-2575*.

fire alarm systems; fire departments; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; *NBS-GCR-82-383*.

fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; sprinkler systems; bibliographies; evacuation; *NBSIR 81-2438*.

fire cause; fire data; fire fatalities; fire statistics; heating equipment; residential fires; rural fires; *NBSIR 82-2519*.

fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; *SP640*; 1982 October. 235-254.

fire data; fire fatalities; fire statistics; heating equipment; residential fires; rural fires; fire cause; *NBSIR 82-2519*.

fire departments; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; *NBS-GCR-82-383*.

fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits; combustion products; compartment fires; egress; *NBSIR 82-2578*.

fire emergency planning; fire protection; group homes; mental disorders; board and care homes; developmentally disabled; elderly persons; evacuation; *NBS-GCR-82-408*.

fire enclosure; fluid flow; Lanczos smoothing; partial differential equations; stream function; vorticity; buoyant convection; finite difference computations; *J. Res. 87(2)*: 165-185; 1982 March-April.

fire endurance; fire engineering design; liquid pool fires; thermoplastic pool fires; wood crib fires; compartment fires; 21093.

fire endurance; fire tests; flame through; floors; furnace tests; joists; steel; wood; *NBSIR 82-2488*.

fire engineering design; liquid pool fires; thermoplastic pool fires; wood crib fires; compartment fires; fire endurance; 21093.

fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; sprinkler systems; bibliographies; evacuation; fire alarm systems; *NBSIR 81-2438*.

fire fatalities; fire statistics; heating equipment; residential fires; rural fires; fire cause; fire data; *NBSIR 82-2519*.

fire fatalities; hydrogen cyanide; alcohol; carbon monoxide; carboxyhemoglobin; cardiovascular disease; 20812.

fire flame length; plume fires; ceiling entrainment; 21094.

fire growth; fire models; heat flux; mathematical models; walls; aircraft compartments; aircraft fires; ceilings; compartment fires; computer programs; *NBS-GCR-82-404*.

fire growth; fire tests; flammability; flashover; interior finishes; room fires; compartment fires; correlations; corridor tests; *NBSIR 82-2525*.

fire growth; flashover; heat release rate; physical modeling; room fires; scale models; *NBSIR 81-2453*.

fire growth; fuel load; heat release rate; prison cell fire; smoke; *NBSIR 82-2469*.

fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits; combustion products; compartment fires; egress; fire detection; *NBSIR 82-2578*.

fire investigation; fire modeling; fire protection; human behavior; smoke control; smoldering; sprinkler systems; toxicity; arson; building design; combustion products; *SP639*.

fire investigations; firesetters; accelerants; arson; decision analysis; 21256.

fire losses; fire safety; residential buildings; smoke detectors; sprinkler systems; cost benefit analysis; decision analysis; *NBSIR 82-2551*.

fire modeling; fire protection; human behavior; smoke control; smoldering; sprinkler systems; toxicity; arson; building design; combustion products; fire investigation; *SP639*.

fire modeling; fire retardancy; fire tests; flame retardancy; oxygen index test; 21275.

fire models; fire plumes; heat transfer; radiation; turbulence; ceilings; *NBS-GCR-81-304*.

fire models; fire tests; flame spread; ignition; particle board; *NBSIR 82-2557*.

fire models; fire tests; home fires; hospitals; mattresses; nursing homes; room fires; smoldering; fabric flammability; *NBSIR 81-2440*.

fire models; heat flux; mathematical models; walls; aircraft compartments; aircraft fires; ceilings; compartment fires; computer programs; fire growth; *NBS-GCR-82-404*.

fire plumes; flame size; flame structure; room fires; ceilings; diffusion flames; entrainment; *NBS-GCR-82-402*.

fire plumes; flow rates; opening flows; air flows; compartment fires; entrainment; *NBSIR 82-2520*.

fire plumes; heat transfer; radiation; turbulence; ceilings; fire models; *NBS-GCR-81-304*.

fire protection; fire safety; human behavior in fires; human factors; Life Safety Code; means of egress; emergency egress; *NBSIR 82-2480*.

fire protection; group homes; mental disorders; board and care homes; developmentally disabled; elderly persons; evacuation; fire emergency planning; *NBS-GCR-82-408*.

fire protection; human behavior; smoke control; smoldering; sprinkler systems; toxicity; arson; building design; combustion products; fire investigation; fire modeling; *SP639*.

fire research; fire tests; flame research; smoke; bibliographies; building fires; coal mines; combustion products; compartment fires; fabric flammability; *NBSIR 82-2499*.

fire research; geotechnical research; illumination; structural research; thermal performance; building research; equipment research; 20896.

fire research; human performance; modeling; pedestrian movement; regulatory process; simulation of human behavior; building codes; building fires; computer-aided design; computer simulation; emergency egress; 20911.

fire resistance; fire tests; flow measurement; gas temperatures; heat release rate; interior finishes; residential buildings; room fires; building fires; *NBSIR 80-2120*.

fire resistance; fire tests; international; ISO; standards; Technical Advisory Group; ASTM; building materials; 21139.

fire retardancy; fire tests; flame retardancy; oxygen index test; fire modeling; 21275.

fires; fire size; fuels; heat of combustion; heat release rate; plastics; ventilation; *NBS-GCR-82-395*.

fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; sprinkler systems; bibliographies; evacuation; fire alarm systems; fire fatalities; *NBSIR 81-2438*.

fire safety; fire tests; flues; heating equipment; stoves; wood; chimneys; creosote; *NBS-GCR-82-368*.

fire safety; flues; heating equipment; stoves; tar; temperature measurements; wood; chimneys; creosote; *NBS-GCR-81-365*.

fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; building economics; economic analysis; 20909.



fire safety; human behavior in fires; human factors; Life Safety Code; means of egress; emergency egress; fire protection; *NBSIR 82-2480*.

fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; *NBSIR 82-2562*.

fire safety; life safety; room fires; sidewall sprinkler systems; thermal response; automatic sprinklers; compartment fires; *NBSIR 82-2521*.

fire safety; residential buildings; smoke detectors; sprinkler systems; cost benefit analysis; decision analysis; fire losses; *NBSIR 82-2551*.

firesetters; accelerants; arson; decision analysis; fire investigations; *21256*.

firesetters; motives; psychiatry; psychopathic personality; psychopathology; arson; behavior disorder; fire; *21335*.

fire size; fuels; heat of combustion; heat release rate; plastics; ventilation; fires; *NBS-GCR-82-395*.

fire statistics; heating equipment; residential fires; rural fires; fire cause; fire data; fire fatalities; *NBSIR 82-2519*.

fire tests; flame attachment; heat flux; ignition; room fires; wall coverings; building materials; *NBSIR 82-2503*.

fire tests; flame research; smoke; bibliographies; building fires; coal mines; combustion products; compartment fires; fabric flammability; fire research; *NBSIR 82-2499*.

fire tests; flame retardancy; oxygen index test; fire modeling; fire retardancy; *21275*.

fire tests; flame spread; ignition; mass loss; test methods; calorimeters; correlation; energy transfer; *NBSIR 82-2536*.

fire tests; flame spread; ignition; particle board; fire models; *NBSIR 82-2557*.

fire tests; flame spread; plastics; smoke chamber; tables; ASTM E162; *NBSIR 81-2400*.

fire tests; flame through; floors; furnace tests; joists; steel; wood; fire endurance; *NBSIR 82-2488*.

fire tests; flammability; flashover; interior finishes; room fires; compartment fires; correlations; corridor tests; fire growth; *NBSIR 82-2525*.

fire tests; flammability; furnishings; upholstered furniture; chairs; compartment fires; *21092*.

fire tests; flashover; room fires; standards; building fires; building materials; committees; *21118*.

fire tests; flow measurement; gas temperatures; heat release rate; interior finishes; residential buildings; room fires; building fires; fire resistance; *NBSIR 80-2120*.

fire tests; flues; heating equipment; literature reviews; radiant energy; stoves; wall protection; walls; wood; chimneys; *NBSIR 82-2506*.

fire tests; flues; heating equipment; stoves; wood; chimneys; creosote; fire safety; *NBS-GCR-82-368*.

fire tests; full-scale; smoke; smoke density chamber; optical density; test methods; visibility; correlation; *NBSIR 82-2508*.

fire tests; heat release rate; oxygen consumption; room fires; calorimeters; *NBSIR 81-2427-1*.

fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; building fires; compartment fires; doors; egress; *21121*.

fire tests; high temperature tests; aggregates; concretes; creep tests; *NBS-GCR-82-407*.

fire tests; histories; test methods; ASTM E-5; *20789*.

fire tests; home fires; hospitals; mattresses; nursing homes; room fires; smoldering; fabric flammability; fire models; *NBSIR 81-2440*.

fire tests; international; ISO; standards; Technical Advisory Group; ASTM; building materials; fire resistance; *21139*.

fire tests; roofing fire resistance; roofing fire tests; solar collectors; *NBSIR 81-2344*.

fire tests; roofing fire resistance; roofing fire tests; solar collectors; *21134*.

fire tests; standards; ASTM E-5; *20805*.

first kind integral equation; ill-posed problems; Lanczos algorithm; regularization; *20778*.

first-surface mirrors; specular reflectance; specular standards; standard mirrors; standard reference material; absolute reflectance; aluminum mirrors; *SP260-75*.

fission cross section; uranium-235; 14 MeV neutron energy; associated particle; *20861*.

fissure detection; fissures; vapor crack detection; ceramic crack detection; ceramic cracks; ceramic fissures; crack detection; *SP400-72*; 1982 April. 201-211.

fissures; vapor crack detection; ceramic crack detection; ceramic cracks; ceramic fissures; crack detection; fissure detection; *SP400-72*; 1982 April. 201-211.

fitness-for-service; fracture mechanics; J-integral; crack opening displacement; finite element analysis; *21194*.

fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; *21236*.

fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; *21223*.

fittings; fixtures; low flows; plumbing products; appliances; *SP624*; 1982 June. 289-292.

fixed antennas; law enforcement; performance standard; radiation pattern; relative antenna gain; antenna; base station; *20901*.

fixed offset frequency; main atomic peak; microwave power level changes; servo; sidelobe atomic peak; atomic clock; atomic resonance frequency error; *U.S. Patent 4,331,933*.

fixed points; International Practical Temperature Scale of 1968; platinum resistance thermometry; *20932*.

fixed points; liquid <sup>3</sup>He; superconductivity; temperature; transition temperature; tungsten; beryllium; *21063*.

fixed points; superconductivity; superfluidity; tungsten; beryllium; *21219*.

fixed points; symposium; temperature scale; thermometers; thermometry; *J. Res. 87(5): 387-406*; 1982 September-October.

fixtures; low flows; plumbing products; appliances; fittings; *SP624*; 1982 June. 289-292.

Fizeau; interferometer; laser wavelength meter; wavemeter; *20862*.

flame; inhibition; inorganic; powder; pyrolysis; retardant; smolder; thermogram; cellulose; combustion; *20799*.

flame angle; openings; plume; room fire; entrainment; *20810*.

flame atomic emission spectrometry; interlaboratory performance; reference method; serum sodium analysis statistics; *21206*.

flame attachment; heat flux; ignition; room fires; wall coverings; building materials; fire tests; *NBSIR 82-2503*.

flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; *20999*.

flame research; heat flux; methane; buoyancy; diffusion flames; *NBS-GCR-82-367*.

flame research; smoke; bibliographies; building fires; coal mines; combustion products; compartment fires; fabric flammability; fire research; fire tests; *NBSIR 82-2499*.

flame retardancy; oxygen index test; fire modeling; fire retardancy; fire tests; *21275*.

flames; ionization; multiphoton; optogalvanic; two photons; energy transfer; *21132*.

flame size; flame structure; room fires; ceilings; diffusion flames; entrainment; fire plumes; *NBS-GCR-82-402*.

flame spray process; plasma coatings; thermal deposition systems; thermospray process; wear; aluminum non-skid coating; corrosion control; erosion; *SP640*; 1982 October. 194-196.

flame spread; gas phase; heat transfer; laminar flame; Laser Doppler Velocimeter; opposed flow; solid fuel; Damkohler number; *NBS-GCR-82-388*.

flame spread; ignition; mass loss; test methods; calorimeters; correlation; energy transfer; fire tests; *NBSIR 82-2536*.

flame spread; ignition; particle board; fire models; fire tests; *NBSIR 82-2557*.

flame spread; plastics; smoke chamber; tables; ASTM E162; fire tests; *NBSIR 81-2400*.

flame spread; polymers; room fires; thermal degradation; ceilings; charring; compartment fires; corridors; *NBS-GCR-82-377*.

flame spread; pyrolysis; solid fuels; additives; computer models; *NBS-GCR-82-396*.

flame stabilization; laser-induced fluorescence; polycyclic aromatic hydrocarbons; recirculation; soot formation; diffusion flames; *21343*.

flame structure; room fires; ceilings; diffusion flames; entrainment; fire plumes; flame size; *NBS-GCR-82-402*.

flame through; floors; furnace tests; joists; steel; wood; fire endurance; fire tests; *NBSIR 82-2488*.

flaming; flashover; nonresidential; residential; scenario; smoldering; cigarettes; codes; escape; fatalities; fire; *20775*.

flaming combustion; inhalation; materials; nonflaming combustion; test method; toxicity; combustion products; *NBSIR 82-2532*.

flammability; flashover; interior finishes; room fires; compartment



fires; correlations; corridor tests; fire growth; fire tests; *NBSIR 82-2525*.

flammability; furnishings; upholstered furniture; chairs; compartment fires; fire tests; *21092*.

flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; textiles; upholstered furniture; cigarettes; fabrics; *21128*.

flammability regulations; flashover; furniture flammability; room fire tests; burning rate; compartment fires; *21089*.

flare stars; late-type stars; stellar chromospheres; stellar coronae; ultraviolet spectra; *21405*.

flashover; furniture flammability; room fire tests; burning rate; compartment fires; flammability regulations; *21089*.

flashover; heat release rate; physical modeling; room fires; scale models; fire growth; *NBSIR 81-2453*.

flashover; interior finishes; room fires; compartment fires; correlations; corridor tests; fire growth; fire tests; flammability; *NBSIR 82-2525*.

flashover; nonresidential; residential; scenario; smoldering; cigarettes; codes; escape; fatalities; fire; flaming; *20775*.

flashover; room fires; standards; building fires; building materials; committees; fire tests; *21118*.

flash photolysis; hydroxyl radicals; nitric acid; rate constant; resonance fluorescence; stratospheric ozone; chemical kinetics; *21040*.

flat plate; shear; strength; building; collapse; concrete; concrete strength; construction; failure; *BSS145*.

flaw analysis from radiographs; flaw depth determinations; pipeline radiographic inspection; radiographic nondestructive testing; weld flaw inspection; *SP621*; 1982 October. 165-173.

flaw depth determinations; pipeline radiographic inspection; radiographic nondestructive testing; weld flaw inspection; flaw analysis from radiographs; *SP621*; 1982 October. 165-173.

flaw detection; horizontally polarized shear waves; stainless steel; ultrasonic testing; elastic anisotropy; *21253*.

flaws; nondestructive evaluation; nondestructive testing; scattering; variational method; elastic waves; *21239*.

flexibility; hydrogen exchange; protein structure; refinement; ribonuclease; amide protection; *21137*.

flicker noise; frequency-domain stability; frequency stability; oscillator noise modeling; power law spectrum; time-domain stability; white noise; *21209*.

flicker noise; frequency stability; oscillator noise modeling; power law spectra; time-domain stability; white noise; *21284*.

float method; small solid objects; solid object density scale; density measurement; *J. Res. 87(3)*: 197-206; 1982 May-June.

flood forces; foundations; load capacity; mobile homes; soil anchors; soil mechanics; stiffness; wind forces; anchors; cyclic loading; field testing; *BSS142*.

floors; furnace tests; joists; steel; wood; fire endurance; fire tests; flame through; *NBSIR 82-2488*.

Florida; Georgia; newspaper recovery; North Carolina; resource recovery; South Carolina; cellulosic insulation; *NBS-GCR-82-371*.

flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus; surface roughness; surface topography; disks; drag; *TN1151*.

flow; horizontal; motion; partially-filled pipe; slope; solid; stream-depth; surge; transport; velocity; water; equation; *NBSIR 81-2450*.

flow calorimetry; kilogram-size samples; municipal solid waste; refuse-derived fuel; sample characterization; sample variability; calorific value; *NBSIR 82-2491*.

flow calorimetry; municipal solid waste; refuse; refuse-derived-fuel; 25 gram capacity flow calorimeter; enthalpy of combustion; *NBSIR 82-2457*.

flow control devices; multi-housing properties; plumbing fixtures; water consumption; water-saving plumbing; control water flow; *SP624*; 1982 June. 47-51.

flow control valve; heat pump; stratification; test method; water heater; energy conservation; energy consumption; *NBSIR 81-2372*.

flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; elasticity; *21175*.

flowing afterglow; fluoride ion; infrared chemiluminescence; ion-molecule reactions; vibration product states; *20784*.

flow measurement; gas temperatures; heat release rate; interior finishes; residential buildings; room fires; building fires; fire resistance; fire tests; *NBSIR 80-2120*.

flow of information; on-line system; system performance; *SP500-95*; 1982 October. 41-45.

flow rates; mathematical models; wind effects; aircraft compartments; aircraft fires; *NBSIR 82-2537*.

flow rates; opening flows; air flows; compartment fires; entrainment; fire plumes; *NBSIR 82-2520*.

flow reduction; groundwater law; public awareness; toilet dams; wastewater flow reduction; water conservation; faucet aerators; *SP624*; 1982 June. 151-154.

flow reduction; plumbing; water conservation; water fixtures; water heating facilities; *SP624*; 1982 June. 281-288.

flow reduction; wastewater treatment; *SP624*; 1982 June. 81-90.

flow reductions; water conservation; *SP624*; 1982 June. 471-477.

fluctuations; nonequilibrium phase transitions; nonlinear optics; optical bistability; second harmonic generation; self pulsing; subharmonic generation; dispersive bistability; *20918*.

flue gas desulfurization; Gibbs energy osmotic coefficients; thermochemical tables; activity coefficients; binary aqueous systems; enthalpies of dilution; enthalpy; entropy; *NBSIR 81-2345*.

fluence scaling; graphite phantom; ionization chamber; water phantom; cobalt-60 gamma rays; Compton scatter; *21055*.

flues; heating equipment; literature reviews; radiant energy; stoves; wall protection; walls; wood; chimneys; fire tests; *NBSIR 82-2506*.

flues; heating equipment; stoves; tar; temperature measurements; wood; chimneys; creosote; fire safety; *NBS-GCR-81-365*.

flues; heating equipment; stoves; wood; chimneys; creosote; fire safety; fire tests; *NBS-GCR-82-368*.

fluid density; hydrostatic weighing; magnetic suspension; capacitance sensing; electronic balance; feedback control; *21207*.

fluid dynamics; mathematical modeling; numerical methods; unsteady flow; vortex shedding; computer simulation; external aerodynamics; *21044*.

fluid flow; instrumentation; irradiance; measurements; solar; temperature; *21349*.

fluid flow; Lanczos smoothing; partial differential equations; stream function; vorticity; buoyant convection; finite difference computations; fire-enclosure; *J. Res. 87(2)*: 165-185; 1982 March-April.

fluid mechanics; meteorology; structural engineering; wind; climatology; extreme winds; *21212*.

fluid structure; nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; radial distribution function; shear; soft sphere fluid; viscosity; computer simulation; *21237*.

fluorescence; ionization; laser ionization; metal vapors; radiation trapping; resonance radiation; *21289*.

fluorescence branching ratios; kinetics; rare gas halides; rate coefficients; excimer lasers; *21299*.

fluoride ion; infrared chemiluminescence; ion-molecule reactions; vibration product states; flowing afterglow; *20784*.

flux deviation; moisture effects; composites; elastic properties; *21196*.

fluxmeters; pulsed current measurements; Rogowski coils; current sensors; *SP628*; 1982 June. 175-193.

flywheel; iron alloy; mass density; mechanical property; titanium alloy; alloy; aluminum alloy; elastic constants; *NSRDS-NBS61, Part V*.

FM spectroscopy; laser frequency control; optical heterodyne spectroscopy; precision laser spectroscopy; *21170*.

foam; gas conduction; guarded-hot-plate; insulation; low temperature; radiation; solid conduction; thermal conductivity; convection; *NBSIR 82-1664*.

fold plane roughening; melt crystallization; polyethylene; polyethylene fold planes; polymer; polymer crystallization; SANS; semicrystalline polymer; adjacent reentry; *21160*.

fold surface; loops; polymer; semicrystalline polymer; tie molecules; amorphous phase; crystal-amorphous interface; *21159*.

food additives; indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; *NBSIR 81-2314*.

food matrices; methods of measurement; nutrients; SRM's; stability; vitamins; *SP635*.

food packaging; heat stabilizers; migration; octyltins; poly(vinyl chloride); diffusion; extraction; *21325*.

food packaging; inverse gas chromatography; migration; oligomers; polyethylene; polypropylene; radiotracer; antioxidants; diffusion; ethylene-vinyl acetate copolymers; *NBSIR 82-2472*.

force constants; gas phase; infrared spectrum; matrix isolation; methyl-*d*<sub>3</sub> nitrite; methyl nitrite; nitromethane; photolysis; *21302*.

forecast; funding sources; intelligent computer programs; knowledge



engineering; machine intelligence; overview; research; state-of-the-art; applications; artificial intelligence; expert systems; *NBSIR 82-2505*.

forecast; Japan; overview; research and development; robot; state-of-the-art; applications; *NBSIR 82-2479*.

forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; *SP631*.

forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems; artificial intelligence; automation; computational; computer perception; computer vision; *NBSIR 82-2582*.

forecasting; synthetic software; acquisition benchmarks; benchmark construction; *SP500-95*; 1982 October. 443-448.

foreign regulations; GATT; notification program; standards code; trade; *21145*.

formal analysis; software testing; software verification; static analysis; test coverage; validation; V,V&T techniques; V,V&T tools; automated software tools; dynamic analysis; *SP500-93*.

formaldehyde; HNO; hydrogen bonding; infrared spectrum; matrix isolation; methyl nitrite; photodecomposition; CH<sub>30</sub>; *21301*.

formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidoxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; *21254*.

formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidoxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; *21255*.

formal description techniques; protocol specification methods; automatic implementation techniques; communication protocols; computer network protocols; *21034*.

format structure; machine-readable cataloging; machine-readable data files; MARC; MRDF; numeric data files; software summary; ANSI Z39.2; bibliographic control; FIPS 30; *SP500-94*; 1982 October. 189-196.

form factor; ground state transition width; inelastic electron scattering; magnetic dipole; Rosenbluth separation; 10.3 MeV transition; <sup>40</sup>Ca; *21037*.

form factor; Rayleigh scattering; tabulation; water; x rays; coherent scattering; cross section; *JPCRD 11(4)*; 1091-1098; 1982.

formwork; post-tensioning; structural analysis; bridge; collapse; concrete; construction; failure investigation; falsework; field load tests; *NBSIR 82-2593*.

FORTRAN; gate blocks; measurement assurance; statistical control; statistical tests; computer software; *TN1168*.

FORTTRAN program; metric symmetry; reduced cell; crystallography; data analysis; determinative ratios; *21269*.

forward scattering; quenching; resonance; sodium; transport; backscattering; experiment; *20953*.

foundation design; hammer; in-situ tests; Standard Penetration Test; boring; drilling; energy; field tests; *20951*.

foundations; load capacity; mobile homes; soil anchors; soil mechanics; stiffness; wind forces; anchors; cyclic loading; field testing; flood forces; *BSS142*.

Fourier analysis; piezoelectric polymers; polarization distribution; thermal pulse experiment; charge distribution; computer analysis; data reduction; *21155*.

Fourier analysis; waveform; discrete Fourier transform; *21404*.

Fourier equation; radiative cooling; specific heat; thermal diffusivity; calorimetry; *J. Res. 87(6)*: 513-526; 1982 November-December.

Fourier series; lunar theory; satellite theory; celestial mechanics; *21030*.

four-point bend test; fracture test; initial value problem; load-displacement characteristics; power-law crack growth; ceramic fracture test; crack growth of ceramics; *NBSIR 82-2504*.

fraction; friction coefficient; growth rate; polyethylene; régime I; régime II; reptation; crystallization; *21158*.

fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; *20955*.

fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; failure detection

systems; *SP621*.

fracture; fracture surface; fracture toughness; analysis; bridges; crack propagation; failure; fatigue; *SP621*; 1982 October. 95-109.

fracture; glass; static fatigue; strength; subcritical crack growth; cracks; *NBSIR 82-2524*.

fracture analysis; mechanical testing; microstructure; rail vehicles; SEM fractography; cast steels; fatigue crack growth rates; *SP621*; 1982 October. 33-45.

fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; *SP621*.

fracture control; hazardous materials; impact transition; pressurized tank car; stress-rupture; *SP621*; 1982 October. 18-32.

fracture control; nondestructive inspection; quality control; welded steel bridges; *SP621*; 1982 October. 130-142.

fracture (materials); fracture toughness; J-integral; low-temperature tests; stainless steels; computer-aided mechanical tests; cryogenic mechanical properties; *20864*.

fracture mechanics; girth welds; nondestructive evaluation; pipeline; radiography; regulation; defect size measurement; *21189*.

fracture mechanics; girth welds; pipeline; plasticity; strength; stress; toughness; collapse; cracks; defects; failure; *21169*.

fracture mechanics; J-integral; crack opening displacement; finite element analysis; fitness-for-service; *21194*.

fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; *21236*.

fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; *21223*.

fractures; machines; stress systems; tension loading; brittle materials; ductile materials; fatigue; *SP621*; 1982 October. 196-200.

fracture surface; fracture toughness; analysis; bridges; crack propagation; failure; fatigue; fracture; *SP621*; 1982 October. 95-109.

fracture test; initial value problem; load-displacement characteristics; power-law crack growth; ceramic fracture test; crack growth of ceramics; four-point bend test; *NBSIR 82-2504*.

fracture toughness; analysis; bridges; crack propagation; failure; fatigue; fracture; fracture surface; *SP621*; 1982 October. 95-109.

fracture toughness; J-integral; low-temperature tests; stainless steels; computer-aided mechanical tests; cryogenic mechanical properties; fracture (materials); *20864*.

Franck-Condon factors; surface reactions; trajectories; vibrational spectroscopy; electron-hole pairs; *21178*.

free-air chamber; ionizing radiation; measurement standards; radiation dosimetry; standards; calorimeter; cavity ionization chamber; extrapolation chamber; *SP609*; 1982 February. 29-30.

free-bond absorption; gain cross section; alkali dimers; excimer laser; *21322*.

free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables; critically evaluated data; enthalpy; entropy; equilibrium constant of formation; *JPCRD 11(3)*: 695-940; 1982.

free-free transitions; Nd laser; photon-assisted transitions; angular distributions; close-coupling approximation; CO<sub>2</sub> laser; elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; *20787*.

free radicals; gamma radiation; hexa (hydroxyethyl) pararosanine; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; *20905*.

free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; *NSRDS-NBS72*.

freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; aluminum point; cadmium point; check thermometers; *SP260-77*.

freight car truck; railroad accidents; railroad freight car; railroad testing; reliability; derailments; fatigue; *SP621*; 1982 October. 3-17.

frequency analysis; rectification; alternating voltage; charge-transfer; corrosion; electrochemistry; *20886*.

frequency averaged energy loss; microdosimetric parameters; bin-averaged cross sections; dose-averaged energy loss; energy deposition spectra; energy distributed neutron spectra; *21029*.

frequency domain; quantizing error; signal-to-noise ratio; time domain; transient recorder; analog-to-digital converter; digitizer; dynamic



testing; effective number of bits; *SP634*; 1982 June. 7-21.

frequency-domain stability; frequency stability; oscillator noise modeling; power law spectrum; time-domain stability; white noise; flicker noise; *21209*.

frequency drift; frequency stability; hydrogen hyperfine separator; hydrogen maser; timekeeping; *21192*.

frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; satellite; shuttle time; time and frequency metrology; time comparisons; Doppler cancellation; *21201*.

frequency response; interferometric measurements; Kerr effect; Pockels effect; polarization; accuracy; calibration; electro-optical measurements; *SP628*; 1982 June. 1-19.

frequency scanned laser; rapid frequency scanning; ring dye laser; single frequency dye laser; tuneable laser; *20791*.

frequency stability; hydrogen hyperfine separator; hydrogen maser; timekeeping; frequency drift; *21192*.

frequency stability; oscillator noise modeling; power law spectra; time-domain stability; white noise; flicker noise; *21284*.

frequency stability; oscillator noise modeling; power law spectrum; time-domain stability; white noise; flicker noise; frequency-domain stability; *21209*.

frequency standard; ion storage; laser cooling; atomic clock; atomic frequency standard; atomic spectroscopy; *21191*.

frequency standard; microwave frequency standard; optical frequency standard; stored ions; atomic clock; atomic frequency standard; atomic spectroscopy; *21202*.

frequency standard evaluation; frequency standard uncertainties; NBS-6; primary standard; cavity phase shift; cesium clock; *21251*.

frequency standards;  $\text{Hg}^+$ ; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure;  $\text{Ba}^+$ ; blackbody radiation; Cs; *21217*.

frequency standards;  $\text{Hg}^+$ ; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure;  $\text{Ba}^+$ ; blackbody radiation; Cs; *21205*.

frequency standards; international atomic time; relativity; satellite clocks; SI second; synchronization; syntonization; time scales; coordinate time; *21188*.

frequency standards; lasers; metrology; spectroscopy; atomic beams; cesium; *21252*.

frequency standard uncertainties; NBS-6; primary standard; cavity phase shift; cesium clock; frequency standard evaluation; *21251*.

frequency transfer; Global Positioning System; international time comparison; primary frequency standards; SI second; automatic time comparison; deep space network; differential time transfer; *21204*.

Fresnel-integrals; interpolation; splines; approximation; clothoids; computer-aided design; Cornu-spirals; curvature; curve fitting; *J. Res. 87(4)*: 317-346; 1982 July-August.

friction coefficient; growth rate; polyethylene; régime I; régime II; reptation; crystallization; fraction; *21158*.

friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus; surface roughness; surface topography; disks; drag; flow; *TN1151*.

friction reduction; pipes; potable water; pressure reduction; residential buildings; sprinkler systems; water; corrosion; *NBS-GCR-82-399*.

FT-IR; infrared; interferograms, tertiary; methods, analytic; silicon; techniques, spectroscopic; *20828*.

fuel cells; gas turbines; high temperature needs; materials problems; MHD; *21260*.

fuel consumption; mobile home; overall system efficiency; residential furnaces; room temperature; thermal response factors; thermostat control; burner on-time; cyclic rates; dynamic simulation computer model; *20903*.

fuel load; heat release rate; prison cell fire; smoke; fire growth; *NBSIR 82-2469*.

fuel oil; petroleum; petroleum testing; processed used oil; recycled oil; burner fuel; *21394*.

fuels; heat of combustion; heat release rate; plastics; ventilation; fires; fire size; *NBS-GCR-82-395*.

fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review; additives; antioxidants; basestocks; chemiluminescence; *NBSIR 82-2490*.

fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; *TN1051*.

fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; *Monogr. 170*.

fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; *Monogr. 169*.

full-scale; smoke; smoke density chamber; optical density; test methods; visibility; correlation; fire tests; *NBSIR 82-2508*.

functional; large sample, convex; regression; statistical methods; structural; errors in variable; *J. Res. 87(1)*: 67-70; 1982 January-February.

functional specification; mandatory requirements; optional requirements; procurement; relational; standards; database management; DBMS; *NBS-GCR-82-372*.

functional subsystem; line replaceable units; malfunction; microprocessor controlled test set; symptom; test strategy; automated test equipment; fault isolation diagnostics; *SP640*; 1982 October. 223-234.

functions; laboratory accreditation; product certification; system operation; accreditation; certification; *SP632*; 1982 March. 24-27.

fundamental constants; silver; silver coulometer; atomic weight; atomic weight of silver; coulometer; electrochemical equivalent; Faraday constant; *J. Res. 87(1)*: 21-22; 1982 January-February.

fundamental research; Government-industry relationships; industrial technology; NBS 80th Anniversary; productivity; science; software edge; *SP627*.

funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; research; state-of-the-art; applications; artificial intelligence; expert systems; forecast; *NBSIR 82-2505*.

fungi; xanthomegnin; absolute configuration; crystal structure; dimer; *21313*.

furnace anneal; ion implant; silicon; deep-level transient spectroscopy (DLTS); defect levels; dopant profiles; *NBS-GCR-81-364*.

furnace tests; joists; steel; wood; fire endurance; fire tests; flame through; floors; *NBSIR 82-2488*.

furnishings; furniture; mattress flammability; room fire tests; smoke density chamber; smoke measurement; *21095*.

furnishings; upholstered furniture; chairs; compartment fires; fire tests; flammability; *21092*.

furniture; mattress flammability; room fire tests; smoke density chamber; smoke measurement; furnishings; *21095*.

furniture flammability; room fire tests; burning rate; compartment fires; flammability regulations; flashover; *21089*.

fused salts; molten salts; self-diffusion coefficients; diffusion; diffusion coefficients; diffusion techniques; *JPCRD 11(3)*: 505-693; 1982.

fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene; atactic; crystal; crystallinity; density; enthalpy; *JPCRD 11(2)*: 313-325; 1982.

fusion; nuclear effects simulation; particle beam technology; pulse power; transients; voltage measurements; current measurement; electrical measurements; electromagnetic pulse; *SP628*.

future plans; implementation; objectives; purpose; facility design; *SP609*; 1982 February. 77-79.

f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; *21185*.

## G

$\text{Ga}^+$ ; ionization;  $\text{Zn}^+$ ; crossed beams; electron impact; excitation-autoionization; *21071*.

$\text{GaAs}$ ; gallium arsenide; infrared elasto-optic; optic phonon; oscillator strength; photoelastic; piezobirefringence; dispersion; effective charge; *21085*.

gadolinium; neodymium; samarium; spectrum; tantalum; tungsten; ytterbium; barium; dysprosium; energy levels; erbium; *20845*.

gage blocks; measurement assurance; statistical control; statistical tests; computer software; FORTRAN; *TN1168*.

Ga II; resonance line; absolute cross section; crossed beams; electron-ion collisions; excitation; *21317*.



gain cross section; alkali dimers; excimer laser; free-bond absorption; 21322.

galaxies, photometry; galaxies, stellar content; galaxies, structure; 20993.

galaxies, stellar content; galaxies, structure; galaxies, photometry; 20993.

galaxies, structure; galaxies, photometry; galaxies, stellar content; 20993.

gallium arsenide; infrared elasto-optic; optic phonon; oscillator strength; photoelastic; piezobirefringence; dispersion; effective charge; GaAs; 21085.

gallium arsenide; potential profiling; spreading resistance; contacts; *NBSIR 81-2403*.

gallium doped silicon; resistivity profiles silicon; spreading resistance; thyristor; aluminum-doped silicon; dopant profiles; 21083.

gallium-tin alloys; levitation calorimetry; segregation; specific heat; surface tension; thermophysical properties; tungsten; Auger spectroscopy; convection; *NBSIR 82-2560*.

galvanic corrosion; implant materials; implants; passivity; pitting; corrosion; crevice corrosion; 20881.

gambler's ruin problem; Monte Carlo; polyethylene; polymer; polymer between two plates; rotational isomeric state model; switchboard model; 21138.

gamma radiation; hexa (hydroxyethyl) pararosiline; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; 20905.

gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; 20902.

gamma radiation; plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; relative humidity effects; temperature effects; dosimetry; dyes; 20975.

gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; *SP609*; 1982 February. 171-178.

gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; 20974.

gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; power transistors; radiation effects; semiconductor devices; VDMOS; drain-source resistance; electron devices; 21000.

gamma ray; microchannel plate; multiple-pinhole mask; spectrometer; telescope; x ray; digitizing anode; 21366.

gamma ray diagnostic technique; current measurements; *SP628*; 1982 June. 267-276.

gamma-ray dosimetry; leuco cyanides; neutron dosimetry; optical waveguides; radiochromic dyes; anomalous dispersion; dimethyl sulfoxide; dosimetry; fibre optics; 20804.

gamma rays; humidity effects; leucocyanides; pulse radiolysis; radiation processing; radiochromic dyes; bleaching of dyes; dose rate; dosimetry; dyes; film dosimetry; 20844.

gamma-ray spectrometry; germanium-detector efficiencies; long-lived-mixed radionuclide standard; uncertainties in gamma-ray measurements; calibration of gamma-ray detector efficiencies; emission-rate measurements; 20874.

gamma-ray standards; precision measurement; x-ray interferometry; x rays; crystal diffraction; 21086.

gas analysis; gases in hermetic packages; hermetic IC packages; internal water vapor; mass spectroscopy; moisture measurement; *SP400-72*; 1982 April. 15-18.

gas analysis; hermetic IC packages; in-situ moisture monitor; internal water vapor; moisture measurement; surface conductivity moisture monitor; *SP400-72*; 1982 April. 64-75.

gas chromatograph; mass spectrometer; SF<sub>6</sub>; streamer pulses; sulfurhexafluoride; water vapor; corona discharges; electron avalanches; 21379.

gas chromatograph-mass spectrometer; H<sub>2</sub>O; sulfur hexafluoride; corona discharge; corona pulse characteristics; decomposition products; 21247.

gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; 20999.

gas chromatography; octanol/water partition coefficients; activity coefficients; alkylbenzenes; *J. Res. 87(4)*: 311-315; 1982 July-August.

gas chromatography; octanol/water partition coefficients; solubility parameters; activity coefficients; *J. Res. 87(2)*: 155-158; 1982 March-April.

gas chromatography/mass spectrometry; leachables; mammary prosthesis; polymeric implants; prolyl hydroxylase; enzymatic assay; *NBSIR 81-2436*.

gas conduction; guarded-hot-plate; insulation; low temperature; radiation; solid conduction; thermal conductivity; convection; foam; *NBSIR 82-1664*.

gaseous fuel mixtures; heating value; hydrocarbon gases; ideal gas; real gas; reference measurement conditions; calorific value; enthalpy of combustion; estimation from composition; *NBSIR 82-2401*.

gases in hermetic packages; hermetic IC packages; internal water vapor; mass spectroscopy; moisture measurement; gas analysis; *SP400-72*; 1982 April. 15-18.

gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; software; sorption; water; algorithms; calibration; chemical reactions; *SP400-72*; 1982 April. 3-7.

gas furnace; heat pump; simplified calculation; air conditioner; energy analysis; equipment performance; 21141.

gas-liquid chromatography; liquid crystals; polycyclic aromatic hydrocarbons; wall-coated open-tubular columns; 20965.

gas phase; heat transfer; laminar flame; Laser Doppler Velocimeter; opposed flow; solid fuel; Damkohler number; flame spread; *NBS-GCR-82-388*.

gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; *NSRDS-NBS72*.

gas phase; infrared spectrum; matrix isolation; methyl-d<sub>3</sub> nitrite; methyl nitrite; nitromethane; photolysis; force constants; 21302.

gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; 21254.

gas phase; ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; 21255.

gas phase; photo-absorption cross section; photochemistry; quantum yield; rate coefficient; air pollution; atmospheric chemistry; chemical kinetics; data evaluation; *JPCRD 11(2)*: 327-496; 1982.

gas phase reaction; stabilized Criegee intermediate; sulfur dioxide removal; *U.S. Patent 4,351,810*.

gas supply models; investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; *SP631*.

gas temperatures; heat release rate; interior finishes; residential buildings; room fires; building fires; fire resistance; fire tests; flow measurement; *NBSIR 80-2120*.

gas thermometry; high-temperature platinum resistance thermometers; temperature fixed points; thermistor thermometers; thermocouple thermometers; thermodynamic temperatures; thermometry; automatic resistance bridges; 21019.

gas transfer; mass spectrometer; moisture measurement; oxygen; software; sorption; water; algorithms; calibration; chemical reactions; gas flow; *SP400-72*; 1982 April. 3-7.

gas transmission; permeation; permeation time-lag; SRM 1470; standard reference materials; automation; computer control; 21026.

gas turbines; high temperature needs; materials problems; MHD; fuel cells; 21260.

gated diode; generation lifetime; integrated gated-diode electrometer; integrated test structure; leakage current; open-circuit voltage decay; surface recombination velocity; electrical test structure; 21143.

gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; *NBSIR 81-2413*.

GATT; notification program; standards code; trade; foreign regulations; 21145.

gauche defect; Raman scattering; straight chain section; accordion-type oscillation; drawn polyethylene; 20790.

Gaussian assumptions; membrane filter method; statistical



considerations; airborne asbestos; error distributions; *SP619*; 1982 March. 145-153.

Gd; Ho; Nd; Pr; Sm; Tb; wavelength; Ce; energy levels; Eu; 20877.

gearboxes; helicopter transmission; pitting; rolling element bearings; rolling fatigue; spalling; filtration; *SP640*; 1982 October. 326-347.

gear train; planet bearings; planetary gears; bearing life; bearings; epicyclic system; *SP640*; 1982 October. 130-149.

generalized inverses; Hamiltonian mechanics; Lie algebras; nonlinear oscillations; normalization; representation theory; *NBSIR 82-2541*.

generalized oscillator strength; electron energy loss; electron impact excitation; electron spectroscopy; 21058.

general lighting; illumination energy; lighting energy; task lighting; building energy performance; building subsystem energy criteria; energy conservation in lighting; 21042.

general needs; historical; laboratory evaluation; accreditation; *SP632*; 1982 March. 28-35.

general physics; medical physics; nonionizing radiation; nuclear medicine; radiation therapy; data handbook; diagnostic radiology; *H138*.

general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; system parameters; transportable computer software; ANSI FORTRAN; computer independent; double precision; *TN1163*.

general purpose computers; magnetic tape units; terminals; disk units; Federal Government computers; Federal minicomputers; Federal statistics; *SP500-97*.

general relativity; gravitation; null experiments; relativity; Eötvös experiment; fibers; 20954.

generation lifetime; integrated gated-diode electrometer; integrated test structure; leakage current; open-circuit voltage decay; surface recombination velocity; electrical test structure; gated diode; 21143.

generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; satellite; shuttle time; time and frequency metrology; time comparisons; Doppler cancellation; frequency reference; 21201.

geodesy; geophysics; gravity; tectonics; absolute gravity; 21318.

geophysics; gravity; tectonics; absolute gravity; geodesy; 21318.

Georgia; newspaper recovery; North Carolina; resource recovery; South Carolina; cellulosic insulation; Florida; *NBS-GCR-82-371*.

geotechnical research; illumination; structural research; thermal performance; building research; equipment research; fire research; 20896.

geothermal brines; metals; nuclear waste; underground; alloys; containers; corrosion; corrosion data; *NBSIR 81-2409*.

germanium; heavily doped semiconductors; impurity levels; silicon; anisotropic Yukawa potential; finite element; 20830.

germanium-detector efficiencies; long-lived-mixed radionuclide standard; uncertainties in gamma-ray measurements; calibration of gamma-ray detector efficiencies; emission-rate measurements; gamma-ray spectrometry; 20874.

germanium resistance thermometers; IPTS-68; magnetic thermometers; NQR thermometers; rhodium-iron thermometers; thermistors; EPT-76; 20933.

Germi energy; silicon; Yukawa potential; bandgap narrowing; band states; donor impurities; 20921.

Gibbs energy; inorganic chemistry; thermochemistry; chemical thermodynamics; enthalpy; entropy; evaluated data; *JPCRD 11(Suppl. 2)*: 394 pp.; 1982.

Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; *NBSIR 81-2356*.

Gibbs energy function; heat capacity; heat of formation; thermochemical tables; critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; *JPCRD 11(3)*: 695-940; 1982.

Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; *JPCRD 11(1)*: 83-99; 1982.

Gibbs energy osmotic coefficients; thermochemical tables; activity coefficients; binary aqueous systems; enthalpies of dilution; enthalpy; entropy; flue gas desulfurization; *NBSIR 81-2345*.

girth welds; nondestructive evaluation; pipeline; radiography; regulation; defect size measurement; fracture mechanics; 21189.

girth welds; pipeline; plasticity; strength; stress; toughness; collapse; cracks; defects; failure; fracture mechanics; 21169.

glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; 20930.

glass; luminescence; melts; oxidation; reduction; terbium; 21315.

glass; mass concentrations; water samples; chrysotile asbestos; fiber; *SP619*; 1982 March. 121-131.

glass; nonferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles; directory; ferrous metals; *NBS-GCR-82-366*.

glass; physical dimensions; analytical standards; asbestos standards; chemical composition; fibers; *SP619*; 1982 March. 21-28.

glass; sodium boron; sodium borosilicate; thermodynamics; transpiration; vaporization; boric oxide; 21108.

glass; static fatigue; strength; subcritical crack growth; cracks; fracture; *NBSIR 82-2524*.

glass-epoxy; graphite-epoxy; internal friction; shear modulus; sound velocity; ultrasonic wave; Young's modulus; boron-aluminum; elastic constants; 20868.

glass-faced terminal; graphic design; software documentation; *SP500-94*; 1982 October. 230-235.

glass formation; glass transition; polymer glasses; equilibrium theory; 21067.

glass sealed; integrated circuit; packages; quality control; thermal shock; Cerdip; *SP400-72*; 1982 April. 234-238.

glass standards; homogeneity testing; microhomogeneity; mineral glasses; standard reference material; chemical analysis; digital periodic integrator; electron probe microanalysis; *SP260-74*.

glass transition; heat capacity; isotactic; linear macromolecule; melt; polystyrene; atactic; crystal; crystallinity; density; enthalpy; fusion; *JPCRD 11(2)*: 313-325; 1982.

glass transition; heat capacity; linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid); enthalpy; entropy; *JPCRD 11(4)*: 1065-1089; 1982.

glass transition; polymer glasses; equilibrium theory; glass formation; 21067.

glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; *SP640*; 1982 October. 257-274.

glazing materials; transparent armor; armor; ballistic protection; ballistic resistant materials; bulletproof glass; 20910.

glazing transmission; shading algorithms; solar access; solar radiation data; urban solar application; daylighting; *NBSIR 82-2498*.

glide; inclusion; kink; tetragonal; Burgers vector; defect; dislocation; 20973.

Global Positioning System; international time comparison; primary frequency standards; SI second; automatic time comparison; deep space network; differential time transfer; frequency transfer; 21204.

glossary; materials handling; robotics; robots; automation; computer aided manufacturing; *NBSIR 81-2340*.

glucose in serum; glucose reference method; isotope dilution/mass spectrometry; reference method; statistical analysis; clinical analysis; *SP260-80*.

glucose reference method; isotope dilution/mass spectrometry; reference method; statistical analysis; clinical analysis; glucose in serum; *SP260-80*.

glycol antifreeze stability; heat transfer liquid; hose; hose immersion test; hose specification; rubber hose; solar energy systems; *NBSIR 81-2352*.

gold; nickel; photoelectrons; surface analysis; Auger electrons; copper; 20986.

gold; silver; single crystal; thin films; aluminium; clusters; copper; 21012.

governmental regulations; manufacturer; tractor model; exporting; *SP632*; 1982 March. 59-60.

Government and industry; protocol standards; telecommunications; computer networks; distributed data; 21265.

government careers; in-service training; physics classroom experiments; statistical consulting course; statistics; training; accuracies, comparison of; 20947.

Government-industry relationships; industrial technology; NBS 80th Anniversary; productivity; science; software edge; fundamental research; *SP627*.

government operated; laboratory accreditation; Nuclear Regulatory Commission; *SP632*; 1982 March. 63-64.



graded materials; inhomogeneous media; jellium; optical reflections; reflection coefficient; Riccati equation; surface reflections; wave impedance; electromagnetic waves; *TN1171*.

grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures; education programs; *SP629*.

grant data; residential buildings; solar data base; solar energy system; solar hot water, space heating and cooling; automatic data processing; computer reports; *NBSIR 81-2376*.

graph; incidence sequence; loopless graph; partition; degree sequence; *J. Res. 87(1): 75-78; 1982 January-February*.

graphical presentation; IBM VM/SP; performance evaluation; performance measurement; performance prediction; VMAP; *SP500-95; 1982 October. 331-359*.

graphic design; software documentation; glass-faced terminal; *SP500-94; 1982 October. 230-235*.

graphic shapes; magnetic ink characters; MICR; MICR Read Optically; OCR; optical character recognition; character shapes; data entry; Federal Information Processing Standard; *FIPS PUB 32-1*.

graphite-epoxy; internal friction; shear modulus; sound velocity; ultrasonic wave; Young's modulus; boron-aluminum; elastic constants; glass-epoxy; *20868*.

graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; *21272*.

graphite phantom; ionization chamber; water phantom; cobalt-60 gamma rays; Compton scatter; fluence scaling; *21055*.

grating; monochromator; synchrotron radiation; toroidal grating monochromator; vacuum ultraviolet monochromator; far ultraviolet radiation; *21079*.

gravitation; null experiments; relativity; Eötvös experiment; fibers; general relativity; *20954*.

gravitational constant; Newtonian gravitational constant; *20968*.

gravitational radiation decay of binary orbits; binary stellar evolution; cataclysmic variables; compact binary x-ray sources; *21010*.

gravitational wave detector; harmonic oscillator; precision measurements; quantum limits; quantum nondemolition; quasi-coherent states; *20980*.

gravity; tectonics; absolute gravity; geodesy; geophysics; *21318*.

gravity effects; light scattering; critical phenomena in space; critical point; dielectric constant; *20875*.

grazing incidence; monochromator efficiency; synchrotron radiation; toroidal grating; ultrahigh vacuum; vacuum ultraviolet; *21069*.

greases; solid lubricant additive; abrasive wear; antimony thioantimonate; extreme pressure and antiwear properties; *SP640; 1982 October. 150-161*.

Great Lakes region; hazardous waste management; paint manufacturing; resource recovery; solvent recovery; steel manufacturing; electroplating; *NBS-GCR-82-405*.

Green's function; input impedance; probe antenna; radiation resistance; rectangular coaxial transmission line; TEM cell; variational method; *TN1054*.

Greenwich; Royal Observatory; time ball; time signals; chronometers; *21024*.

gross leak test; helium; hermeticity; tracer gas; bombing; fine leak test; *SP400-72; 1982 April. 281-288*.

ground state constants; infrared spectrum; low temperature spectrum; torsional splittings; C-H stretching region; difference-frequency laser; Doppler-limited resolution; ethane; *J. Res. 87(3): 237-256; 1982 May-June*.

ground state transition width; inelastic electron scattering; magnetic dipole; Rosenbluth separation; 10.3 MeV transition;  $^{40}\text{Ca}$ ; form factor; *21037*.

ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; *SP621*.

groundwater law; public awareness; toilet dams; wastewater flow reduction; water conservation; faucet aerators; flow reduction; *SP624; 1982 June. 151-154*.

groundwater resources; water conservation planning; water resource development; water resources; *SP624; 1982 June. 197-206*.

group homes; mental disorders; board and care homes; developmentally disabled; elderly persons; evacuation; fire emergency planning; fire protection; *NBS-GCR-82-408*.

group theory; nuclear spin; rovibronic species; statistical weights; symmetric top molecules; *21300*.

growth rate; polyethylene; régime I; régime II; reptation; crystallization; fraction; friction coefficient; *21158*.

g-sensing derailment detector; local derailment; nitinol sensor; on-board failure detection system; overheated bearings; thermal switch sensor; train line; contact derailment sensor; *SP621; 1982 October. 49-68*.

guarded hot plate; heat flow meter; heat transfer; low-density mineral fiber; thermal conductivity; thermal resistance; thickness effect; building insulation; energy conservation; *NBSIR 82-2538*.

guarded-hot-plate; insulation; low temperature; radiation; solid conduction; thermal conductivity; convection; foam; gas conduction; *NBSIR 82-1664*.

guarded-hot-plate apparatus; insulation; low-temperature; thermal conductivity; *NBSIR 81-1657*.

guidelines; bibliographic data; data element dictionary; *SP500-94; 1982 October. 209-214*.

guidelines; life-cycle; software; specifications; standards; documentation; *SP500-87*.

guidelines; local area networks; local network specification; requirements analysis; feature analysis; *SP500-96*.

guidelines; procedures; software; compatibility; *SP500-94; 1982 October. 80-83*.

guidelines; program documentation; software documentation; standards; documentation; *FIPS; SP500-94*.

guys; mechanical testing; nondestructive testing; pultrusions; standards; composite materials; damage; fatigue; *21195*.

## H

hail damage; hail impact testing; hail launcher; simulated hail testing; solar collector covers; test method development; *NBSIR 82-2487*.

hail impact testing; hail launcher; simulated hail testing; solar collector covers; test method development; hail damage; *NBSIR 82-2487*.

hail launcher; simulated hail testing; solar collector covers; test method development; hail damage; hail impact testing; *NBSIR 82-2487*.

half lives; measurement uncertainties; photon probabilities per decay; relative photon-emission probabilities; compilation; efficiency data; *SP626*.

Hall effect; inversion layer; Landau level; MOSFET; density of states; *20942*.

Hall effect; Landau levels; resistance standard; silicon MOSFETs; two-dimensional electron gas; fine-structure constant; *21220*.

haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; *NSRDS-NBS70*.

halocarbon; halogen; iron; adsorption; chemisorption; dissociation; *21154*.

halogen; iron; adsorption; chemisorption; dissociation; halocarbon; *21154*.

Hamiltonian; parallax transformation; third-order solution; transformation; artificial satellite; *21381*.

Hamiltonian mechanics; Lie algebras; nonlinear oscillations; normalization; representation theory; generalized inverses; *NBSIR 82-2541*.

hammer; in-situ tests; Standard Penetration Test; boring; drilling; energy; field tests; foundation design; *20951*.

Hanawalt search procedure; powder diffraction file; x ray; crystal data; diffraction; *21271*.

handcuffs; triple backing; *U.S. Patent 4,314,466*.

handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; *NBS-GCR-82-383*.

handicapped; pressurization; smoke control; stairwells; building fires; egress; elevators (lifts); evacuation; *NBSIR 82-2507*.

handicapped; pressurization; smoke control; stairwells; building fires; egress; elevators; *21226*.

Hanle effect; radiation-matter interaction; *21320*.

hardening shrinkage; hygroscopic expansion; polymerization; water sorption; adsorption; composite resins; expansion; *21052*.

hard rods; molecular dynamics; non-ergodic; relaxation; velocity



autocorrelation; distribution functions; 21283.

hard sphere gas; kinetic models; Enskog equation; 20890.

hard spheres; propane; viscosity; corresponding states; Enskog model; equation of state; 21225.

hardware; installation; locking device classification; lock operation; characteristics; door security; entry control; *NBSIR 81-2233*.

hardware; measurement; third generation ATE; third generation core system; ATE systems; calibration; computer; *SP640*; 1982 October. 222.

hardware monitoring; performance measurement; Shuttle Mission Simulator; UNIVAC; disk I/O; *SP500-95*; 1982 October. 217-230.

hardware systems documentation; large computer manufacturers; microcomputers; periodical literature and documentation; software documentation; user's groups; verbal documentation; beginning computer users; documentation; *SP500-94*; 1982 October. 174-179.

harmonic oscillator; precision measurements; quantum limits; quantum nondemolition; quasi-coherent states; gravitational wave detector; 20980.

hazard; pictograms; pictorial; safety; signs; standards; symbols; visual alerting; warning; communication; design issues; *BSSI41*.

hazard analysis; hospitals; interstitial space; mattresses; smoke control; smoke exhaust; smoke movement; ventilation systems; ceiling systems; *NBSIR 81-2444*.

hazard analysis; mathematical models; room fires; smoke movement; tenability limits; combustion products; compartment fires; egress; fire detection; fire growth; *NBSIR 82-2578*.

hazardous materials; impact transition; pressurized tank car; stress-rupture; fracture control; *SP621*; 1982 October. 18-32.

hazardous waste management; lab procedures; Louisiana; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; *NBS-GCR-81-349*.

hazardous waste management; lab procedures; Mississippi; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; *NBS-GCR-81-353*.

hazardous waste management; lab procedures; model manual; monitoring; Resource Conservation and Recovery Act; State measurement needs; test protocols; analytical procedures; *NBS-GCR-81-355*.

hazardous waste management; lab procedures; Oklahoma; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; *NBS-GCR-81-350*.

hazardous waste management; lab procedures; Pennsylvania; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; *NBS-GCR-81-351*.

hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; training; Virginia; analytical procedures; *NBS-GCR-81-354*.

hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; *NBS-GCR-81-348*.

hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; Texas; training; analytical procedures; *NBS-GCR-81-352*.

hazardous waste management; paint manufacturing; resource recovery; solvent recovery; steel manufacturing; electroplating; Great Lakes region; *NBS-GCR-82-405*.

head protectors; armor; ballistic helmets; ballistic impact; ballistic threat levels; bulletproof helmets; 20913.

health and safety; housing; mathematical programming; rehabilitation; renovation; applied economics; building codes; *NBSIR 81-2416*.

health and safety; passive design; solar energy; standards; building regulations; buildings; energy; enforcement; *NBSIR 82-2554*.

health care facilities; hospital mattresses; smoke movement; sprinkler systems; clothing wardrobes; 20793.

health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; building economics; economic analysis; fire safety; 20909.

health care facilities; life cycle cost; Life Safety Code; automatic sprinklers; building codes; building construction; *NBSIR 82-2558*.

health monitoring; tribology; wear; wear debris analysis; diagnostics; ferrography; *SP640*; 1982 October. 466-475.

Health Physics Society; neutrons; photons; standard; testing program; conversion factors; dose equivalent; field measurement; 20813.

health risk; polarized light microscopy; asbestos; bulk standards; construction materials; *SP619*; 1982 March. 34-43.

heart disease; heavy metals; hydrogen chloride; scenario; alcohol; carbon monoxide; cigarettes; fatalities; fire; 20858.

heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; 20930.

heat capacity; heat of formation; thermochemical tables; critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; *JPCRD 11(3)*: 695-940; 1982.

heat capacity; high temperature; standard reference material; synthetic sapphire; aluminum oxide; corundum; drop calorimetry; enthalpy; *J. Res. 87(2)*: 159-163; 1982 March-April.

heat capacity; isotactic; linear macromolecule; melt; polystyrene; atactic; crystal; crystallinity; density; enthalpy; fusion; glass transition; *JPCRD 11(2)*: 313-325; 1982.

heat capacity; linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid); enthalpy; entropy; glass transition; *JPCRD 11(4)*: 1065-1089; 1982.

heat capacity; moisture effect; phenolic resin; specific heat; thermosetting polymers; varnishes; adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; 21032.

heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties; argon; critically evaluated data; density; ethylene; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

heat capacity; saturated liquid; specific heat; thermodynamic properties; coexistence; ethylene; 21187.

heat capacity; thermodynamics; elements; enthalpy; entropy; evaluated data; 20819.

heat defect; radiation chemistry; thermistor; water; absorbed dose; calorimeter; convection; *J. Res. 87(3)*: 211-235; 1982 May-June.

heat exchanger; modeling; monitoring; research; steam; thermal response; valve; air conditioning; building systems; computer; control; 21048.

heat flow; laboratory tests; soil moisture; soil tests; tests; thermal conductivity; thermal resistivity; Atterberg Limit tests; compaction; compaction tests; *BSSI49*.

heat flow meter; heat transfer; low-density mineral fiber; thermal conductivity; thermal resistance; thickness effect; building insulation; energy conservation; guarded hot plate; *NBSIR 82-2538*.

heat flux; ignition; room fires; wall coverings; building materials; fire tests; flame attachment; *NBSIR 82-2503*.

heat flux; mathematical models; walls; aircraft compartments; aircraft fires; ceilings; compartment fires; computer programs; fire growth; fire models; *NBS-GCR-82-404*.

heat flux; methane; buoyancy; diffusion flames; flame research; *NBS-GCR-82-367*.

heat flux; radiation; turbulence; buoyancy; cross-correlation; diffusion flames; entrainment; *NBSIR 82-2473*.

heating; heating seasonal performance; heating seasonal performance factor; heat pumps; test method; water source heat pumps; central heating equipment; cooling; *NBSIR 81-2287*.

heating; hot water; performance criteria; solar energy; standards; building; cooling; *BSSI47*.

heating; hot water; performance criteria; solar energy; standards; buildings; cooling; 21082.

heating and cooling; performance criteria; photovoltaics; solar energy systems; standards; wind energy; biomass; 21106.

heating equipment; literature reviews; radiant energy; stoves; wall protection; walls; wood; chimneys; fire tests; flues; *NBSIR 82-2506*.

heating equipment; residential fires; rural fires; fire cause; fire data; fire fatalities; fire statistics; *NBSIR 82-2519*.

heating equipment; stoves; tar; temperature measurements; wood; chimneys; creosote; fire safety; flues; *NBS-GCR-81-365*.

heating equipment; stoves; wood; chimneys; creosote; fire safety; fire tests; flues; *NBS-GCR-82-368*.

heating seasonal performance; heating seasonal performance factor; heat pumps; test method; water source heat pumps; central heating equipment; cooling; heating; *NBSIR 81-2287*.

heating seasonal performance factor; heat pumps; test method; water source heat pumps; central heating equipment; cooling; heating; heating seasonal performance; *NBSIR 81-2287*.

heating value; hydrocarbon gases; ideal gas; real gas; reference measurement conditions; calorific value; enthalpy of combustion; estimation from composition; gaseous fuel mixtures; *NBSIR 82-2401*.

heating, ventilating and air-conditioning controls; humidity; humidity control; humidity measurement; humidity sensor; hygrometer;



building energy monitoring; *NBSIR 81-2460*.  
 heat of combustion; heat release rate; plastics; ventilation; fires; fire size; fuels; *NBS-GCR-82-395*.  
 heat of formation; thermochemical tables; critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; *JPCRD 11(3): 695-940; 1982*.  
 heat of mixing; benzene; cyclohexane; evaluation procedures; excess enthalpy; *JPCRD 11(4): 1129-1151; 1982*.  
 heat of mixing; liquid density; mixtures; second virial coefficients; vapor-liquid equilibrium; vapor pressure; volume change of mixing; equations of state; *JPCRD 11(3): 941-951; 1982*.  
 heat-pipe furnace; Na vapor; sodium *K* absorption; *21329*.  
 heat pump; life-cycle costs; benefit-cost analysis; energy conservation; equipment selection; equipment sizing; *NBSIR 80-2176*.  
 heat pump; simplified calculation; air conditioner; energy analysis; equipment performance; gas furnace; *21141*.  
 heat pump; stratification; test method; water heater; energy conservation; energy consumption; flow control valve; *NBSIR 81-2372*.  
 heat pumps; heat pump test methods; microcomputer; analog signal conditioning; data acquisition system; field data acquisition; field instrumentation; field performance of heat pumps; *NBSIR 81-2285*.  
 heat pumps; rating procedure; seasonal cost of operation; test method; central air conditioners; *NBSIR 81-2434*.  
 heat pumps; test method; water source heat pumps; central heating equipment; cooling; heating; heating seasonal performance; heating seasonal performance factor; *NBSIR 81-2287*.  
 heat pump test methods; microcomputer; analog signal conditioning; data acquisition system; field data acquisition; field instrumentation; field performance of heat pumps; heat pumps; *NBSIR 81-2285*.  
 heat-recovery; insulation; measurement; office-building; radiant; solar; space-heating; air-cooling; air leakage; energy; *20961*.  
 heat recovery; total energy system; absorption chillers; boiler performance; central utility plant; diesel engine performance; engine-generator efficiency; environmental impact; *NBSIR 82-2474*.  
 heat release rate; interior finishes; residential buildings; room fires; building fires; fire resistance; fire tests; flow measurement; gas temperatures; *NBSIR 80-2120*.  
 heat release rate; oxygen consumption; room fires; calorimeters; fire tests; *NBSIR 81-2427-1*.  
 heat release rate; physical modeling; room fires; scale models; fire growth; flashover; *NBSIR 81-2453*.  
 heat release rate; plastics; ventilation; fires; fire size; fuels; heat of combustion; *NBS-GCR-82-395*.  
 heat release rate; prison cell fire; smoke; fire growth; fuel load; *NBSIR 82-2469*.  
 heats of formation; procedure; chlorinated benzenes; chlorinated dioxins; chlorinated phenols; estimation; *21346*.  
 heat stabilizers; migration; octylins; poly(vinyl chloride); diffusion; extraction; food packaging; *21325*.  
 heat transfer; hot water; measurement; rating; solar; standards; testing; energy; *21264*.  
 heat transfer; laminar flame; Laser Doppler Velocimeter; opposed flow; solid fuel; Damkohler number; flame spread; gas phase; *NBS-GCR-82-388*.  
 heat transfer; low-density mineral fiber; thermal conductivity; thermal resistance; thickness effect; building insulation; energy conservation; guarded hot plate; heat flow meter; *NBSIR 82-2538*.  
 heat transfer; natural convection; nonlinear convection; numerical integration; transient fluid motion; transient heat transfer; compressible fluid motion; convection; finite difference approximation; *NBSIR 82-1660*.  
 heat transfer; radiation; turbulence; ceilings; fire models; fire plumes; *NBS-GCR-81-304*.  
 heat transfer in buildings; night space cooling; night ventilation; passive solar heating; building thermal mass; dynamic performance of buildings; energy conservation; *BSS137*.  
 heat transfer liquid; hose; hose immersion test; hose specification; rubber hose; solar energy systems; glycol antifreeze stability; *NBSIR 81-2352*.  
 heat transfer liquid degradation kinetics; simulated service test solar collector; corrosion; elevated temperature; *NBSIR 81-2339*.  
 heavily doped semiconductors; impurity levels; silicon; anisotropic Yukawa potential; finite element; germanium; *20830*.  
 heavily doped semiconductors; impurity levels; silicon; finite element; *20851*.  
 heavy metals; hydrogen chloride; scenario; alcohol; carbon monoxide; cigarettes; fatalities; fire; heart disease; *20858*.  
 heavy water; Helmholtz function; *PVT*; specific heats; speed of sound; thermodynamic properties; vapor pressure; enthalpy; equation of state; *JPCRD 11(1): 1-14; 1982*.  
 helical spin structure; holmium single crystal; low temperature; magnetic spin structure; nuclear magnetism; nuclear orientation;  $\gamma$  rays; <sup>166m</sup>Ho-Ho atomic magnetism; *21017*.  
 helicopter transmission; pitting; rolling element bearings; rolling fatigue; spalling; filtration; gearboxes; *SP640; 1982 October. 326-347*.  
 He-like ions; isoelectronic sequence; spectra series; vacuum ultraviolet; x rays; atomic spectra; atomic wavelengths; *20803*.  
 helium; hermeticity; tracer gas; bombing; fine leak test; gross leak test; *SP400-72; 1982 April. 281-288*.  
 helium; saturation density; vapor phase; virial coefficients; Burnett method; equation of state; ethylene; *21228*.  
 Helmholtz function; *PVT*; specific heats; speed of sound; thermodynamic properties; vapor pressure; enthalpy; equation of state; heavy water; *JPCRD 11(1): 1-14; 1982*.  
 HEPA filters; ion counters; ion density; ions; net space charge; corona discharge; *NBSIR 82-2486*.  
 hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; moisture generators; moisture sensors; quality control; reliability of semiconductor devices; semiconductor devices; analysis of moisture content; *SP400-72*.  
 hermetic IC packages; in-situ moisture monitor; internal water vapor; moisture measurement; surface conductivity moisture monitor; gas analysis; *SP400-72; 1982 April. 64-75*.  
 hermetic IC packages; internal water vapor; mass spectroscopy; moisture measurement; gas analysis; gases in hermetic packages; *SP400-72; 1982 April. 15-18*.  
 hermeticity; hybrid; leak test; methanol; silicone coating; UV light; *SP400-72; 1982 April. 271-274*.  
 hermeticity; hybrid microelectronics; hybrid packages; microelectronic packaging; thermal shock; vibration; acoustic emission; *SP400-70*.  
 hermeticity; tracer gas; bombing; fine leak test; gross leak test; helium; *SP400-72; 1982 April. 281-288*.  
 hermetic packages; mass spectrometer; seam sealing; sensor chips; standards; water vapor; dew point; *SP400-72; 1982 April. 49-63*.  
 hermetic packages; moisture; packaging; water vapor; contamination; dew point; *SP400-72; 1982 April. 76-78*.  
 hermetic test; leak testing; back pressurization; electronic packages; *SP400-73*.  
 hermetic test; leak testing; back pressurization; electronic packages; *20856*.  
 heterodyne frequency measurements; infrared spectroscopy; rotational constants; band centers; carbonyl sulfide; diode laser spectra; *20852*.  
 heterodyne spectroscopy; isotope enrichment isotope separation; SiF<sub>4</sub> spectra; CO<sub>2</sub> saturation spectra; diode laser spectra; *21216*.  
 heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; *20825*.  
 hexafluoropropylene; polytetrafluoroethylene; tetrafluoroethylene; x-ray diffraction; copolymers; crystal; *21164*.  
 hexagonal urea lattice; inclusion compounds; microanalysis; normal alkanes; Raman microprobe; Raman spectroscopy; vibrational analysis; *20996*.  
 hexa (hydroxyethyl) pararosanine; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; *20905*.  
 Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; *21217*.  
 Hg<sup>+</sup>; ac Stark shift; ac Zeeman shift; atomic clocks; atomic hyperfine structure; Ba<sup>+</sup>; blackbody radiation; Cs; frequency standards; *21205*.  
 Hg(CH<sub>3</sub>)<sub>2</sub>; laser; photodissociation; CH<sub>3</sub>; *21319*.  
 hierarchical control; manufacturing research; research facility; automated machining; *21378*.  
 hierarchical control systems; automated manufacturing; automatic control; computer-aided design; computer-aided manufacturing simulation; *NBS-GCR-82-414*.  
 hierarchical control systems; simulation; automated manufacturing;



automatic control; computer-aided design; computer-aided manufacturing; *NBS-GCR-82-413*.

hierarchical data model; logical database design; network data model; relational data model; schema design; database design; database management; database modeling; database schema translation; database semantics; entity-relationship model; *NBS-GCR-82-390*.

hierarchy of standards; National Bureau of Standards; radiation; standards; traceability; calibration; definitions; *SP609*; 1982 February. 11-17.

high accuracy; modular capacitive divider; portable system; truck-mounted; CCVT; compact; field calibration; *21287*.

high di/dt particle beam accelerator; Rogowski coils; cavity current monitors; current measurements; current viewing resistors; *SP628*; 1982 June. 266.

high-dose measurements; lithium borate; lyoluminescence; radiochromic dye; alanine; biologic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; *20889*.

high efficiency air particulate (HEPA) filters; ion counters; ion density; measurement; net space charge; electrostatic potential; *NBSIR 82-2517*.

high efficiency particulate air filter; high voltage dc transmission lines; ion counter; ion density; net space charge density; current density measurements; *NBSIR 82-2527*.

high energy; ionization chamber; photon beam; radiation therapy; absorbed dose; calibration; electron beam; *20894*.

high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; survey; teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; *SP609*; 1982 February. 89-97.

high-energy electrons; measurement assurance; radiation therapy; survey; teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; *SP609*; 1982 February. 89-97.

high energy photons; residual stress; energy dispersive diffractometry; *20887*.

high energy photons; residual stress; energy dispersive diffractometry; *21350*.

high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; residual stress; stress measurements; ultrasonics; x-ray diffraction; Barkhausen noise; energy dispersive diffractometry; *20926*.

high-energy x-rays; internal stress; neutron diffraction; nondestructive evaluation; residual stress; stress analysis; x-ray diffraction; diffraction; *21359*.

higher level protocols; interactive program development; layered architecture; time-sharing; user level workloads; Ethernet; Ethernet performance; Ethernet simulation; *SP500-95*; 1982 October. 375-388.

higher-order moments; hot-wire anemometry; lognormal; small-scale turbulence; velocity gradients; *21278*.

high level protocols; networking performance; network protocols; protocol standards; standards; distributed computing; *21386*.

highly excited states of  $E(Z_1, eZ_2)$  system; molecular energy splitting; two-Coulomb-center problem; *21376*.

high order accuracy; Poisson equation; elliptic partial differential equations; finite difference methods; *20779*.

high-performance liquid chromatography; hormones; peptides; angiotensins; anion-exchange; *21294*.

high-performance liquid chromatography; peptides; amino acid analysis; anion-exchange; cytochrome c; enzymatic digestion; *21293*.

high power laser; ionization; multiphoton; nonresonant; atomic sodium; *21003*.

high power measurements; high voltage; overshoot; power semiconductors; reverse-bias second breakdown; testing; voltage; clamping; diode recovery; *20849*.

high precision; load cell; mass comparator; substitution weighing; weighing; constant loading; *J. Res. 87(1)*: 47-48; 1982 January-February.

high pressure; high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; experimental melting curves; *JPCRD 11(4)*: 1005-1064; 1982.

high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; *21272*.

high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; *20999*.

high purity materials; instrumental neutron activation analysis; precision; reference materials; standards; trace analysis; accuracy; *20997*.

high resolution; lithography; photoresists; synchrotron radiation; energy deposition; extreme ultraviolet; *21078*.

high-resolution; molecular spectroscopy; transition moments; tunable lasers; anharmonicity; combination band; *20924*.

high resolution; settling time; step response; analog-to-digital converters; code transition levels; converter testing; dynamic testing; *20908*.

high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; sprinkler systems; bibliographies; evacuation; fire alarm systems; fire fatalities; fires; *NBSIR 81-2438*.

high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; building fires; compartment fires; doors; egress; fire tests; *21121*.

high speed photography; Kerr effect; liquid breakdown; nitrobenzene; partial discharges; streamers; transient phenomena; electrical breakdown; *21328*.

high speed transient digitizers; pulsed power generators; cable attenuation; Fast Fourier Transforms; *SP628*; 1982 June. 381-391.

high temperature; hydrogen isocyanide; infrared; molecular structure; potential functions; spectroscopy; absorption; *20782*.

high temperature; impedance; resistivity; coal slag; conductivity; *21182*.

high temperature; polymorphism; p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; experimental melting curves; high pressure; *JPCRD 11(4)*: 1005-1064; 1982.

high temperature; radiance temperature at melting point; reference points; refractory elements; *21369*.

high temperature; standard reference material; synthetic sapphire; aluminum oxide; corundum; drop calorimetry; enthalpy; heat capacity; *J. Res. 87(2)*: 159-163; 1982 March-April.

high temperature fracture; J-integral; Si-Al-O-N; singular integral equation; crack growth model; creep cavitation; diffusive crack growth; energy release rate; *20931*.

high temperature needs; materials problems; MHD; fuel cells; gas turbines; *21260*.

high-temperature platinum resistance thermometers; temperature fixed points; thermistor thermometers; thermocouple thermometers; thermodynamic temperatures; thermometry; automatic resistance bridges; gas thermometry; *21019*.

high temperatures; proof testing; reliability; silicon nitride; structural ceramics; deformation maps; *NBSIR 81-2445*.

high-temperature series expansions; hyperscaling relations; Ising ferromagnet; Padé and integral approximants; renormalization group; Boson field theory; *21080*.

high temperature tests; aggregates; concretes; creep tests; fire tests; *NBS-GCR-82-407*.

high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; *NBSIR 82-2501*.

high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; *NBSIR 82-2528*.

high voltage; incipient fault; insulation; SF<sub>6</sub>; space charge; transformer oil; cables; dc fields; *NBSIR 82-2586*.

high voltage; insulation; liquids; shock waves; breakdown; dielectrics; *21352*.

high voltage; liquids; partial discharge; polydimethylsiloxanes; breakdown; electrical insulation; *21130*.

high voltage; overshoot; power semiconductors; reverse-bias second breakdown; testing; voltage; clamping; diode recovery; high power measurements; *20849*.

high voltage dc transmission lines; ion counter; ion density; net space charge density; current density measurements; high efficiency particulate air filter; *NBSIR 82-2527*.

high voltage divider; pulse voltage monitor; voltage monitor; waterline voltage monitor; capacity divider; *SP628*; 1982 June. 20-25.

high voltage dividers; partial discharge; transient phenomena; *SP628*;



1982 June. 69-79.  
high voltage measurements; impulse; step response; divider; *SP628*;  
1982 June. 26-33.  
high voltage measurements; revenue metering; calibration; CCVT;  
EHV substations; error sources; *NBSIR 81-2360*.  
high voltage pulser; pulse generators; voltage probes; calibrations;  
capacitance-current; dielectric; *SP628*; 1982 June. 59-68.  
highway transportation; safety; vehicle inspections; *SP621*; 1982  
October. 177-185.  
hip prosthesis; stress analysis; surface preparation; surgical implant  
metals; test method; titanium; bone cement; *NBSIR 82-2563*.  
historical; laboratory evaluation; accreditation; general needs; *SP632*;  
1982 March. 28-35.  
histories; test methods; ASTM E-5; fire tests; *20789*.  
history; International Laboratory Accreditation Conference;  
international testing; laboratory accreditation; acceptance testing;  
accreditation systems; *NBSIR 82-2523*.  
history; international trade; laboratory accreditation; need; criteria;  
definitions; *SP632*.  
HNO; hydrogen bonding; infrared spectrum; matrix isolation; methyl  
nitrite; photodecomposition; CH<sub>3</sub> formaldehyde; *21301*.  
Ho; Nd; Pr; Sm; Tb; wavelength; Ce; energy levels; Eu; Gd; *20877*.  
hole drilling; nondestructive evaluation; photoelasticity; research  
needs; residual stress; standards; stress measurement; terminology;  
ultrasonics; x-ray diffraction; fatigue; *21344*.  
hole-drilling method; neutron diffraction; nondestructive evaluation;  
residual stress; stress measurements; ultrasonics; x-ray diffraction;  
Barkhausen noise; energy dispersive diffractometry; high-energy x  
rays; *20926*.  
holmium single crystal; low temperature; magnetic spin structure;  
nuclear magnetism; nuclear orientation;  $\gamma$  rays; <sup>166m</sup>Ho-Ho atomic  
magnetism; helical spin structure; *21017*.  
home fires; hospitals; mattresses; nursing homes; room fires;  
smoldering; fabric flammability; fire models; fire tests; *NBSIR 81-  
2440*.  
homogeneity testing; microhomogeneity; mineral glasses; standard  
reference material; chemical analysis; digital periodic integrator;  
electron probe microanalysis; glass standards; *SP260-74*.  
homogeneous solution; precipitation from; lattice constant of yttrium-  
doped cerium dioxide; carbonates, cerium-yttrium, coprecipitation  
of; ceramics, ceria-yttria, high-density; ceramics, ceria-yttria, hot-  
pressing of; cerium dioxide, yttrium-doped; cerium-yttrium oxide  
ceramic; cerium-yttrium oxide powders; *21051*.  
horizontal; motion; partially-filled pipe; slope; solid; stream-depth;  
surge; transport; velocity; water; equation; flow; *NBSIR 81-2450*.  
horizontally polarized shear waves; stainless steel; ultrasonic testing;  
elastic anisotropy; flaw detection; *21253*.  
hormones; peptides; angiotensins; anion-exchange; high-performance  
liquid chromatography; *21294*.  
hose; hose immersion test; hose specification; rubber hose; solar  
energy systems; glycol antifreeze stability; heat transfer liquid;  
*NBSIR 81-2352*.  
hose immersion test; hose specification; rubber hose; solar energy  
systems; glycol antifreeze stability; heat transfer liquid; hose;  
*NBSIR 81-2352*.  
hose specification; rubber hose; solar energy systems; glycol antifreeze  
stability; heat transfer liquid; hose; hose immersion test; *NBSIR 81-  
2352*.  
hospital mattresses; smoke movement; sprinkler systems; clothing  
wardrobes; health care facilities; *20793*.  
hospitals; human behavior; nursing homes; panic; smoke detectors;  
sprinkler systems; bibliographies; evacuation; fire alarm systems;  
fire fatalities; fires; high-rise buildings; *NBSIR 81-2438*.  
hospitals; integer programming; mathematical programming; nursing  
homes; optimization; renovation; applied economics; building codes;  
building economics; economic analysis; fire safety; health care  
facilities; *20909*.  
hospitals; interstitial space; mattresses; smoke control; smoke exhaust;  
smoke movement; ventilation systems; ceiling systems; hazard  
analysis; *NBSIR 81-2444*.  
hospitals; mattresses; nursing homes; room fires; smoldering; fabric  
flammability; fire models; fire tests; home fires; *NBSIR 81-2440*.  
host independent; monitor; network; performance; remote; response  
time; series/1; sidestreaming; simulated commands; 327X emulator;  
accurate data; end user; *SP500-95*; 1982 October. 401-407.  
hot tube; laboratory bench tests; oxidation; solubilization; automotive  
crankcase oils; bench test procedures; catalysts; correlation;  
dispersancy; engine sequence tests; *21279*.  
hot water; measurement; rating; solar; standards; testing; energy; heat  
transfer; *21264*.  
hot water; passive solar; performance criteria; solar energy; thermal  
performance; active solar; evaluation process; *NBS-GCR-82-397*.  
hot water; performance criteria; solar energy; standards; building;  
cooling; heating; *BSS147*.  
hot water; performance criteria; solar energy; standards; buildings;  
cooling; heating; *21082*.  
hot wire; oxygen; pressure temperature; thermal conductivity;  
transient; *J. Res. 87(4): 279-310*; 1982 July-August.  
hot-wire anemometry; lognormal; small-scale turbulence; velocity  
gradients; higher-order moments; *21278*.  
household heaters and furnace test procedures; hydraulic thermostat  
control; modulating control gas-fueled; two-stage thermostat;  
annual efficiency; *NBSIR 82-2497*.  
household water conservation program; potable water conservation;  
wastewater treatment; wastewater treatment utilities; water supply  
utilities; *SP624*; 1982 June. 247-258.  
housing; insulation; space heating and cooling costs; space heating and  
cooling requirements; architecture; building design; cost-benefit  
analysis; economics; energy conservation; *NBSIR 81-2380*.  
housing; mathematical programming; rehabilitation; renovation;  
applied economics; building codes; health and safety; *NBSIR 81-  
2416*.  
HUD/MIUS Program; HVAC systems; performance analysis; solid  
waste; total energy; utility systems; abstracted reports and articles;  
coal-fired MIUS; comparison studies; concept background of  
MIUS; conservation of energy; energy analysis; *SP489, Supplement  
1*.  
hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus;  
surface roughness; surface topography; disks; drag; flow; friction  
disk; *TN1151*.  
human behavior; nursing homes; panic; smoke detectors; sprinkler  
systems; bibliographies; evacuation; fire alarm systems; fire  
fatalities; fires; high-rise buildings; hospitals; *NBSIR 81-2438*.  
human behavior; smoke control; smoldering; sprinkler systems;  
toxicity; arson; building design; combustion products; fire  
investigation; fire modeling; fire protection; *SP639*.  
human behavior in fires; human factors; Life Safety Code; means of  
egress; emergency egress; fire protection; fire safety; *NBSIR 82-  
2480*.  
human comfort; indoor environment; outdoor environment; thermal  
comfort; bioclimatic chart; *21004*.  
human factors; Life Safety Code; means of egress; emergency egress;  
fire protection; fire safety; human behavior in fires; *NBSIR 82-  
2480*.  
human factors; passive solar/thermal comfort; performance/thermal  
comfort; temperature drifts/comfort; thermal comfort; ASHRAE  
comfort standards; asymmetric heating/comfort; behavioral studies;  
clothing/thermal comfort; comfort envelope; *NBSIR 82-2585*.  
human health; National Environmental Specimen Bank; specimen  
banking; storage evaluation and analysis; environment; *21126*.  
human interface; on-line documentation; authoring; *SP500-94*; 1982  
October. 236-241.  
human performance; material and material processing; mechanical and  
structural failure; operational environment; preventive maintenance;  
wear; corrosion; failure prevention; *SP640*; 1982 October. 2-16.  
human performance; modeling; pedestrian movement; regulatory  
process; simulation of human behavior; building codes; building  
fires; computer-aided design; computer simulation; emergency  
egress; fire research; *20911*.  
humidity; humidity control; humidity measurement; humidity sensor;  
hygrometer; building energy monitoring; heating, ventilating and  
air-conditioning controls; *NBSIR 81-2460*.  
humidity; hybrids; microcircuits; moisture; moisture sensors;  
reliability; *SP400-72*; 1982 April. 178-183.  
humidity; infrared; microcircuits; moisture; reliability; water vapor;  
derivative spectroscopy; diode laser; *SP400-72*; 1982 April. 105-109.  
humidity; mass spectrometry; moisture sensors; packaging; reliability;  
standard packages; *SP400-72*; 1982 April. 19-31.  
humidity control; humidity measurement; humidity sensor;  
hygrometer; building energy monitoring; heating, ventilating and  
air-conditioning controls; humidity; *NBSIR 81-2460*.  
humidity effects; leucocyanines; pulse radiolysis; radiation processing;  
radiochromic dyes; bleaching of dyes; dose rate; dosimetry; dyes;  
film dosimetry; gamma rays; *20844*.  
humidity measurement; humidity sensor; hygrometer; building energy  
monitoring; heating, ventilating and air-conditioning controls;



humidity; humidity control; *NBSIR 81-2460*.

humidity sensor; hygrometer; building energy monitoring; heating, ventilating and air-conditioning controls; humidity; humidity control; humidity measurement; *NBSIR 81-2460*.

Hund's coupling; WKB approximation; adiabatic electronic-rotational states; atomic scattering; distorted wave approximation; fine structure transitions; 20786.

hurricanes; Weibull; windspeeds; Extreme Type II; 21211.

HVAC system; microprocessor control; pneumatic control system; velocity algorithm; building controls; digital-to-pneumatic conversion; direct digital control; energy controls; 20995.

HVAC system control; parameter estimator; PI-controller; recursive least squares algorithm; self-tuning control algorithm; adaptive control; air handling unit; direct digital control; energy management and control systems; *NBSIR 82-2591*.

HVAC systems; building control strategies; building energy conservation; building thermal performance; *NBSIR 82-2580*.

HVAC systems; performance analysis; solid waste; total energy; utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; *SP489, Supplement 1*.

hybrid; leak test; methanol; silicone coating; UV light; hermeticity; *SP400-72*; 1982 April. 271-274.

hybridization; isomer shift; Mössbauer effect; alloying; alloy phase diagrams; charge transfer; 20820.

hybrid manufacturing; moisture sources; adsorption; corrosion; dew point; failure modes; *SP400-72*; 1982 April. 117-125.

hybrid microcircuit; moisture; nichrome resistors; semiconductor devices; dew point; failure; *SP400-72*; 1982 April. 175-177.

hybrid microelectronics; hybrid packages; microelectronic packaging; thermal shock; vibration; acoustic emission; hermeticity; *SP400-70*.

hybrid packages; microelectronic packaging; thermal shock; vibration; acoustic emission; hermeticity; hybrid microelectronics; *SP400-70*.

hybrids; microcircuits; moisture; moisture sensors; reliability; humidity; *SP400-72*; 1982 April. 178-183.

hybrids; moisture measurement; oxide moisture sensors; *SP400-72*; 1982 April. 110-112.

hydrated phosphate; strontium phosphate; struvite-type structure; crystal structure; 21180.

hydration of  $\text{XO}_4$  ion; magnesium arsenate hydrate; magnesium phosphate hydrate; struvite analogue; water-rich hydrates; crystal structure; 20873.

hydraulic thermostat control; modulating control gas-fueled; two-stage thermostat; annual efficiency; household heaters and furnace test procedures; *NBSIR 82-2497*.

hydride; hydrogen; microscopy; orthorhombic; surfaces; uranium; 21021.

hydrocarbon gases; ideal gas; real gas; reference measurement conditions; calorific value; enthalpy of combustion; estimation from composition; gaseous fuel mixtures; heating value; *NBSIR 82-2401*.

hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; *NSRDS-NBS72*.

hydrocarbons; intramolecular relaxation; laser; vibrational relaxation; 20920.

hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review; additives; antioxidants; basestocks; chemiluminescence; fuels; *NBSIR 82-2490*.

hydro-dynamic condition; lubrication systems; maintenance program; prevention; diagnostic controls; *SP640*; 1982 October. 170-186.

hydrodynamic drag; rotating disk; roughness; ships; stylus; surface roughness; surface topography; disks; drag; flow; friction disk; hulls; *TNI151*.

hydrofluoric acid calorimetry; plantinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; 20930.

hydrogen; hydrogen deuterate; kinetic isotope effect; transition state; zinc oxide; chemisorption; 20971.

hydrogen; hydrogen mixtures; rotational transitions; spectra; absorption coefficient; collision-induced; far infrared spectra; 21165.

hydrogen; iron; Ni(100); carbon monoxide; catalytic activity; dissociation; 20987.

hydrogen; metastable states; optical pumping; atomic beam; 21102.

hydrogen; methanation;  $\text{NH}_3$ ; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111);  $\text{CH}_4$ ; decomposition; heterogeneous catalysis; 20825.

hydrogen; methanol; methoxy; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; 21296.

hydrogen; microscopy; orthorhombic; surfaces; uranium; hydride; 21021.

hydrogen; neutron inelastic scattering; Raney nickel; vibrational spectroscopy; chemisorption; 21295.

hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; enthalpy; equation of state; ethylene; *TNI048*.

hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; *NSRDS-NBS72*.

hydrogen; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; water; 21005.

hydrogen; phase diagram; properties; solid; crystal structure; 20979.

hydrogenated amorphous silicon; optical transmittance; refractive index; scattering matrix; thin film; transmittance extrema; electro-optic modulation; *NBSIR 81-1652*.

hydrogen bonding; infrared spectrum; matrix isolation; methyl nitrite; photodecomposition;  $\text{CH}_3\text{O}$ ; formaldehyde;  $\text{HNO}$ ; 21301.

hydrogen bonds; protein structure; ribonuclease-S; semi-synthetic proteins; x-ray methods; active site; 20914.

hydrogen chemisorption; PLEED; spin dependent electron scattering; temperature phases; 20865.

hydrogen chloride; scenario; alcohol; carbon monoxide; cigarettes; fatalities; fire; heart disease; heavy metals; 20858.

hydrogen cyanide; alcohol; carbon monoxide; carboxyhemoglobin; cardiovascular disease; fire fatalities; 20812.

hydrogen cyanide; polymer; toxicity; autopsy; biological; carboxyhemoglobin; fatalities; 20811.

hydrogen deuterate; kinetic isotope effect; transition state; zinc oxide; chemisorption; hydrogen; 20971.

hydrogen exchange; protein structure; refinement; ribonuclease; amide protection; flexibility; 21137.

hydrogen halide; molecular relaxation; vibration; energy transfer; *JPCRD 11(3)*; 953-996; 1982.

hydrogen hyperfine separator; hydrogen maser; timekeeping; frequency drift; frequency stability; 21192.

hydrogen in metals; impurities; inelastic structure factor; neutron spectroscopy; niobium; tunneling; 20941.

hydrogen in metals; impurity tunneling;  $\text{KBr:CN}^-$ ;  $\text{KCl:CN}^-$ ; neutron scattering; phonon coupling; theory; 20879.

hydrogen isocyanide; infrared; molecular structure; potential functions; spectroscopy; absorption; high temperature; 20782.

hydrogen maser; timekeeping; frequency drift; frequency stability; hydrogen hyperfine separator; 21192.

hydrogen maser clocks; international time; laser ranging; satellite; shuttle time; time and frequency metrology; time comparisons; Doppler cancellation; frequency reference; generation of UTC and TAI; 21201.

hydrogen mixtures; rotational transitions; spectra; absorption coefficient; collision-induced; far infrared spectra; hydrogen; 21165.

hydrogen on diamond; semiconducting diamond; surface reconstruction; surface states; vibrational spectra; deuterium on diamond; diamond(111)  $1 \times 1$ ; EELS; electron energy loss spectroscopy; 21288.

hydrogen peroxide; ion chromatography; sulfur; cadmium sulfide; chloride-doped cadmium sulfide; chlorine; 20859.

hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; 21326.

hydrolysis; kinetics; polyester; polyurethane; acid; carbodiimide; degradation; 20972.

hydrophobic; moisture permeation; polymeric materials; solubility; diffusion; *SP400-72*; 1982 April. 239-245.

hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; 20836.

hydrostatic weighing; magnetic suspension; capacitance sensing; electronic balance; feedback control; fluid density; 21207.

hydroxyalkyl radicals; photolysis; radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl



radicals; chemical kinetics; electron transfer; haloalkyl radicals; *NSRDS-NBS70*.  
 hydroxyapatite; octacalcium phosphate; sodium urate; biominerals; calcium carbonates; calcium oxalates; calcium phosphates; calcium pyrophosphate; crystal structures; *21110*.  
 hydroxyl; laser chemistry; laser excited fluorescence; molecular spectroscopy; multiphoton chemistry; carbene; *21391*.  
 hydroxyl radicals; nitric acid; rate constant; resonance fluorescence; stratospheric ozone; chemical kinetics; flash photolysis; *21040*.  
 hygrometer; building energy monitoring; heating, ventilating and air-conditioning controls; humidity; humidity control; humidity measurement; humidity sensor; *NBSIR 81-2460*.  
 hygrometer; kinetics; microelectronic package; moisture; moisture level; relative humidity; sorption thermodynamics; absorption; adsorption; dew point; *SP400-72*; 1982 April. 184-200.  
 hygroscopic expansion; polymerization; water sorption; absorption; composite resins; expansion; hardening shrinkage; *21052*.  
 hyperbolic shell; shell; collapse; concrete; concrete strength; construction; cooling tower; failure; *BSSI48*.  
 hyperfine constants; lambda doubling; laser magnetic resonance; rotational levels; Zeeman effect; CH; far infrared; *21273*.  
 hyperscaling relations; Ising ferromagnet; Padé and integral approximants; renormalization group; Boson field theory; high-temperature series expansions; *21080*.  
 hysteresis; quartz crystal resonators; quartz resonator thermometry; *20934*.  
 H<sub>2</sub>O; sulfur hexafluoride; corona discharge; corona pulse characteristics; decomposition products; gas chromatograph-mass spectrometer; *21247*.

## I

IBM's RMF; job class; mathematical modeling; performance/modeling data acquisition; software monitor; application of basic queueing theory; *SP500-95*; 1982 October. 279-296.  
 IBM VM/SP; performance evaluation; performance measurement; performance prediction; VMAP; graphical presentation; *SP500-95*; 1982 October. 331-359.  
 IC assembly; in-situ moisture sensors; LSI circuits; mass spectrometry; on-going monitoring activity; package-sealing environment; aluminum oxide; Cerdip packages; *SP400-72*; 1982 April. 113-116.  
 IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; *TN1164*.  
 IC surface; localized corrosion; surface model; corrosion of an IC; *SP400-72*; 1982 April. 129-148.  
 ideal gas; real gas; reference measurement conditions; calorific value; enthalpy of combustion; estimation from composition; gaseous fuel mixtures; heating value; hydrocarbon gases; *NBSIR 82-2401*.  
 ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients; equation of state; ethylene; *21208*.  
 ideal gas thermodynamic properties; internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; *JPCRD 11(1)*; 83-99; 1982.  
 identification; pattern recognition; computerized-fingerprint-identification; *SP500-89*.  
 IEEE 488 Bus; total power radiometer; automated noise measurement system; coaxial noise sources; controller; *NBSIR 81-1656*.  
 ignition; absorption; CO<sub>2</sub> laser; decane; *21304*.  
 ignition; ignition surface temperature; polymethylmethacrylate; radiative ignition; red oak; surface temperature; *21306*.  
 ignition; mass loss; test methods; calorimeters; correlation; energy transfer; fire tests; flame spread; *NBSIR 82-2536*.  
 ignition; particle board; fire models; fire tests; flame spread; *NBSIR 82-2557*.  
 ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; textiles; upholstered furniture; cigarettes; fabrics; flammability; *21128*.  
 ignition; polymethacrylate; radiation; surface temperature; wood; absorption; CO<sub>2</sub> laser; decomposition; *20792*.  
 ignition; polymethylmethacrylate; radiation; red oak; surface temperature; absorption; *21305*.  
 ignition; radiation; solid fuel; absorption; *21314*.

ignition; room fires; wall coverings; building materials; fire tests; flame attachment; heat flux; *NBSIR 82-2503*.  
 ignition surface temperature; polymethylmethacrylate; radiative ignition; red oak; surface temperature; ignition; *21306*.  
 ILAC; laboratories; national programs; accreditation; *SP632*; 1982 March. 76-78.  
 ill-posed problems; Lanczos algorithm; regularization; first kind integral equation; *20778*.  
 illumination; structural research; thermal performance; building research; equipment research; fire research; geotechnical research; *20896*.  
 illumination energy; lighting energy; task lighting; building energy performance; building subsystem energy criteria; energy conservation in lighting; general lighting; *21042*.  
 image analysis; scanning transmission; selected area electron diffraction; transmission electron microscope; electron microscope; energy dispersive x-ray spectrometry; *SP619*; 1982 March. 207-210.  
 image contrast; indentation hardening; plastic deformation; x-ray topography; copper single crystal; *21353*.  
 image formation; kinetic study; materials science; synchrotron radiation; topography; x ray; *21257*.  
 image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; *SP400-74*.  
 image understanding; industrial vision systems; pattern recognition; scene analysis; vision; vision systems; artificial intelligence; automation; computational; computer perception; computer vision; forecasting; *NBSIR 82-2582*.  
 imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; and ultrasonics; acoustic emission; eddy currents; *NBSIR 82-2449*.  
 imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; *NBS-GCR-80-204*.  
 impact transition; pressurized tank car; stress-rupture; fracture control; hazardous materials; *SP621*; 1982 October. 18-32.  
 impedance; polyacetylene; transport; conductivity; electrical; *20853*.  
 impedance; resistivity; coal slag; conductivity; high temperature; *21182*.  
 implant materials; implants; passivity; pitting; corrosion; crevice corrosion; galvanic corrosion; *20881*.  
 implantment by mechanical inclusion; macro-molecular clustering; molybdenum disulphide imbedment; carbide precipitation; decarburization zones; *SP640*; 1982 October. 187-193.  
 implants; passivity; pitting; corrosion; crevice corrosion; galvanic corrosion; implant materials; *20881*.  
 implementation; objectives; purpose; facility design; future plans; *SP609*; 1982 February. 77-79.  
 implementation; PL/I; specifications; validation; assertions; data abstractions; *20943*.  
 improper drilling; time-domain analysis; tool failure; tool wear; vibration signatures; automated manufacturing; drill failure prediction; drill wear; finished dimensions; *20795*.  
 impulse; step response; divider; high voltage measurements; *SP628*; 1982 June. 26-33.  
 impulse measurements; numerical correction; analog-to-digital converters; error caused by response time; *SP628*; 1982 June. 341-354.  
 impulse measuring systems; resistor dividers; response time; voltage measurement; comparative measurements; design; dividers; *SP628*; 1982 June. 34-45.  
 impulse response measurements; low-level laser measurements; modulated cw measurement system; PIN transfer standards; pulse energy; pulse peak power; 1.064  $\mu$ m laser pulse measurements; APD transfer standards; beamsplitter attenuator; *TN1058*.  
 impurities; inelastic structure factor; neutron spectroscopy; niobium; tunneling; hydrogen in metals; *20941*.  
 impurities; silicon; valence states; Yukawa potential; bandgap narrowing; Bargmann potential; conduction states; donors; effective mass; energy dispersion; *20855*.  
 impurity levels; silicon; anisotropic Yukawa potential; finite element; germanium; heavily doped semiconductors; *20830*.  
 impurity levels; silicon; finite element; heavily doped semiconductors;



20851.  
 impurity states; midgap absorption; nonhydrogenic states; polaron; polyacetylene; soliton; doping; 21104.  
 impurity tunneling; KBr:CN<sup>-</sup>; KCl:CN<sup>-</sup>; neutron scattering; phonon coupling; theory; hydrogen in metals; 20879.  
 inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; SP640; 1982 October. 257-274.  
 incentives; metering; rate structures; water conservation; consumer education; energy conservation; feedback; NBSIR 80-2119.  
 incidence sequence; loopless graph; partition; degree sequence; graph; J. Res. 87(1): 75-78; 1982 January-February.  
 incident angle modifier; measurement; solar collector; standards; thermal performance; uncertainty; collector rating; 21387.  
 incident-energy dependence; nickel; electron energy-loss spectra; 20860.  
 incineration; New York City; resource recovery; solid waste management; steam production; destruct heating; electricity production; energy recovery; NBS-GCR-82-409.  
 incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; NBSIR 82-2528.  
 incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; NBSIR 82-2501.  
 incipient fault; insulation; SF<sub>6</sub>; space charge; transformer oil; cables; dc fields; high voltage; NBSIR 82-2586.  
 inclusion; kink; tetragonal; Burgers vector; defect; dislocation; glide; 20973.  
 inclusion compounds; microanalysis; normal alkanes; Raman microprobe; Raman spectroscopy; vibrational analysis; hexagonal urea lattice; 20996.  
 indentation hardening; plastic deformation; x-ray topography; copper single crystal; image contrast; 21353.  
 independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; concept relations; co-occurrence; document retrieval; 21250.  
 independent; laboratory accreditation; manufacturing concerns; commercial; SP632; 1982 March. 57-58.  
 index of refraction of air; refractivity of air; wavelength of light in air; air density; 21276.  
 index profile; measurements; attenuation; bandwidth; fiber optic joints; fiber optics; fiber optics-single mode; SP641.  
 index profile; measurements; optical fiber; attenuation; backscatter; bandwidth; SP637, Volume 1.  
 indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; NBSIR 81-2314.  
 indium doped silicon; isoelectronic; optical properties; photoluminescence; silicon; bound exciton; density of states; 21146.  
 individual; laboratory; accreditation procedures; corporate; Corporate Standard Quality System; SP632; 1982 March. 52-53.  
 indoor environment; outdoor environment; thermal comfort; bioclimatic chart; human comfort; 21004.  
 indoor testing; modeling; NBS; solar; solar domestic hot water system; stratification; test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; BSS140.  
 induced dipole; line shape; rare gas mixtures; spectra; transient dipoles; collision-induced absorption; collision-induced light scattering; far infrared absorption; 21173.  
 induction times; infrared laser; intensity dependence in infrared photochemistry; laser chemistry; laser excited fluorescence; multiphoton dissociation; unimolecular dissociation rates; CF<sub>2</sub>HCl (chlorodifluoromethane); 21342.  
 industrial atmosphere; lead; measurement methods; measurement systems; standard reference materials (SRM's); SP619; 1982 March. 29-33.  
 industrial robots; robots; safety; sensors; ultrasonic; echo-ranging transducer; 20977.  
 industrial technology; NBS 80th Anniversary; productivity; science; software edge; fundamental research; Government-industry relationships; SP627.  
 industrial vision systems; pattern recognition; scene analysis; vision; vision systems; artificial intelligence; automation; computational; computer perception; computer vision; forecasting; image understanding; NBSIR 82-2582.  
 industry; innovation; State and local governments; technology transfer; technology utilization; evaluation; Federal R&D; 20854.  
 industry; International System of Units (SI); metric system; status and future; economic benefits; 21120.  
 inelastic cross-sections; laser; laser-induced collisions; radiation theory; stimulated emission; atomic collisions; close-coupled scattering theory; dressed-atoms; 21347.  
 inelastic electron scattering; magnetic dipole; Rosenbluth separation; 10.3 MeV transition; <sup>40</sup>Ca; form factor; ground state transition width; 21037.  
 inelastic neutron scattering; intercalated systems; lattice dynamics; phonons; two-dimensional systems; C<sub>36</sub>K; 20949.  
 inelastic scattering; O<sub>2</sub>; Rydberg series; angular distributions;  $c \rightarrow \Sigma_u^-$  limit; electrons; experimental; 21077.  
 inelastic scattering; sticking; surface processes; x-ray edge; 21152.  
 inelastic scattering cross section; spin-dependent scattering; elastic scattering cross section; 21101.  
 inelastic structure factor; neutron spectroscopy; niobium; tunneling; hydrogen in metals; impurities; 20941.  
 inequality; majorization; median; statistical methods; concave; convex; J. Res. 87(1): 71-74; 1982 January-February.  
 inertial confinement fusion; Sandia Particle Beam Fusion Accelerator; SuperMite; CAMAC pulse processing modules; SP628; 1982 June. 325-340.  
 inertial confinement fusion studies; pulse generators; Antares; calibration; SP628; 1982 June. 320.  
 inertial mass; piezoelectric polymer films; accelerometer; U.S. Patent 4,315,433.  
 infiltration; natural ventilation; building energy analysis; computer simulation; 21123.  
 inflation; interlibrary lending; journal prices; library photocopying; publishers; book prices; copyright law; 21380.  
 information processing systems; magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; FIPS PUB 93.  
 information processing systems; magnetic tape cassettes; magnetic tape recording; magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; FIPS PUB 91.  
 information processing system standards; project management standards; documentation standards; SP500-94; 1982 October. 160-164.  
 information resource management; database; database design; data dictionary system; data management; DBMS; SP500-92.  
 Information Resource Management; Information Systems Management; management-tool; methodologies; strategies; techniques; concepts; SP500-95; 1982 October. 5-9.  
 information resource management; interactive language; language structure; software; computer program; database; database management system; data dictionary system; data management; data standards; NBS-GCR-82-385.  
 information resource management; interactive language; language structure; software; computer program; database; database management system; data dictionary system; data management; data standards; NBS-GCR-82-387.  
 Information Resource Management; productivity; computer-based applications; data processing; SP500-95; 1982 October. 19-24.  
 information resource management; software; computer program; database; database management system; data dictionary system; data management; data standards; ERA model; NBS-GCR-82-386.  
 information resource management; software; computer program; database; database management system; data dictionary system; data management; data standards; ERA model; NBS-GCR-82-384.  
 information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; 21250.  
 information retrieval; interactive processing; random access; computer indexing; data base; directory look-up; TN1167.  
 information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption;



information retrieval; 21250.

information retrieval systems; information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; 21250.

information retrieval theory; models of concept relations; similarity; term relations; automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; 21250.

information systems; computer program abstracts; software documentation; standards; *SP500-94*; 1982 October. 197-202.

Information Systems Management; management-tool; methodologies; strategies; techniques; concepts; Information Resource Management; *SP500-95*; 1982 October. 5-9.

infrared; interferograms, tertiary; methods, analytic; silicon; techniques, spectroscopic; FT-IR; 20828.

infrared; microcircuits; moisture; reliability; water vapor; derivative spectroscopy; diode laser; humidity; *SP400-72*; 1982 April. 105-109.

infrared; microwave; molecular spectroscopy; rotational spectra; ultraviolet; vibrational spectra; visible; electronic spectra; 21388.

infrared; molecular structure; potential functions; spectroscopy; absorption; high temperature; hydrogen isocyanide; 20782.

infrared; molecular structure; spectroscopy; vibrational spectra; bond distances; carbon diselenide; 20801.

infrared; spectra; air pollution; atmospheric chemistry; chlorine monoxide; ClO; diode laser; 21303.

infrared; spectra; unstable molecules; bond distance; boron chloride; diode lasers; Dunham coefficients; 20817.

infrared chemiluminescence; ion-molecule reactions; vibration product states; flowing afterglow; fluoride ion; 20784.

infrared elasto-optic; optic phonon; oscillator strength; photoelastic; piezobirefringence; dispersion; effective charge; GaAs; gallium arsenide; 21085.

infrared excitation; multiphoton dissociation; product state distributions; review infrared multiphoton dissociation;  $\text{CF}_2\text{HCl}$ ;  $\text{CF}_2\text{CFCl}$ ; 21334.

infrared intensities; molecular polarizabilities; vibrational polarizabilities; atomic polarization; dipole polarizabilities; *JPCRD 11(1)*; 119-133; 1982.

infrared laser; intensity dependence in infrared photochemistry; laser chemistry; laser excited fluorescence; multiphoton dissociation; unimolecular dissociation rates;  $\text{CF}_2\text{HCl}$  (chlorodifluoromethane); induction times; 21342.

infrared spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; cost-effective; data processing; *SP640*; 1982 October. 61-71.

infrared spectroscopy; rotational constants; band centers; carbonyl sulfide; diode laser spectra; heterodyne frequency measurements; 20852.

infrared spectrum; low temperature spectrum; torsional splittings; C-H stretching region; difference-frequency laser; Doppler-limited resolution; ethane; ground state constants; *J. Res. 87(3)*: 237-256; 1982 May-June.

infrared spectrum; matrix isolation; methyl- $d_3$  nitrite; methyl nitrite; nitromethane; photolysis; force constants; gas phase; 21302.

infrared spectrum; matrix isolation; methyl nitrite; photodecomposition;  $\text{CH}_3\text{O}$ ; formaldehyde; HNO; hydrogen bonding; 21301.

infrared spectrum; matrix isolation; phenyl; photodecomposition; 1-fluorocyclohexadienyl; benzene; F-atom reactions; 20917.

ingress; integrated circuit package; moisture; monolayer buildup; egress; *SP400-72*; 1982 April. 258-270.

inhalation; materials; nonflaming combustion; test method; toxicity; combustion products; flaming combustion; *NBSIR 82-2532*.

inhibition; inorganic; powder; pyrolysis; retardant; smolder; thermogram; cellulose; combustion; flame; 20799.

inhomogeneous media; jellium; optical reflections; reflection coefficient; Riccati equation; surface reflections; wave immittance; electromagnetic waves; graded materials; *TN1171*.

initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon; crosslinking; dosimetry; ethylene vinyl acetate; 20900.

initial value problem; load-displacement characteristics; power-law crack growth; ceramic fracture test; crack growth of ceramics; four-point bend test; fracture test; *NBSIR 82-2504*.

inner salt; iodonium compound; ionic bonding; reaction intermediate; x-ray diffraction; crystal structure; 21268.

innershell resonances; photoelectron spectroscopy; rare gases; synchrotron radiation; asymmetry parameter; autoionization; branching ratios; 21291.

innovation; offsets; administrative experiment; air pollution; emissions trading; ETIP; *NBSIR 82-2475*.

innovation; post-marketing surveillance; regulatory experiments; drug development; drug regulation; *NBS-GCR-ETIP 82-99*.

innovation; procurement; regulation; research and development; technology policy; administrative experiments; economic assistance; *NBS-GCR-ETIP 82-100*.

innovation; productivity analysis; computerized analysis; electric utility rate regulation; Experimental Technology Incentives Program; *NBSIR 80-2046*.

innovation; State and local governments; technology transfer; technology utilization; evaluation; Federal R&D; industry; 20854.

inorganic; powder; pyrolysis; retardant; smolder; thermogram; cellulose; combustion; flame; inhibition; 20799.

inorganic chemistry; thermochemistry; chemical thermodynamics; enthalpy; entropy; evaluated data; Gibbs energy; *JPCRD 11(Suppl. 2)*: 394 pp.; 1982.

inplace testing; inspection; nondestructive testing; quality assurance; building materials; concrete; evaluation; *J. Res. 87(5)*: 407-438; 1982 September-October.

input impedance; probe antenna; radiation resistance; rectangular coaxial transmission line; TEM cell; variational method; Green's function; *TN1054*.

input/output; interfaces; automatic data processing (ADP); channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; *FIPS PUB 61-1*.

in-school education; residential water conservation devices; water conservation; water resources planning; water system leak detection; *SP624*; 1982 June. 401-407.

in-school education programs; residential water savings devices; device installation programs; *SP624*; 1982 June. 449-452.

inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve; database; data collection; failure data; 21176.

inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; 21177.

inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve; database; data collection; failure data; inservice data; 21176.

in-service training; physics classroom experiments; statistical consulting course; statistics; training; accuracies, comparison of; government careers; 20947.

in-situ moisture monitor; internal water vapor; moisture measurement; surface conductivity moisture monitor; gas analysis; hermetic IC packages; *SP400-72*; 1982 April. 64-75.

in-situ moisture sensors; LSI circuits; mass spectrometry; on-going monitoring activity; package-sealing environment; aluminum oxide; Cerdip packages; IC assembly; *SP400-72*; 1982 April. 113-116.

in situ test; penetration tests; practice; samplers; soil tests; standard penetration tests; drills; 20867.

in-situ tests; Standard Penetration Test; boring; drilling; energy; field tests; foundation design; hammer; 20951.

inspection; metal distress; metal parts; NDE; nickel base alloys; testing; defect detection; eddy current; failure prevention; ferromagnetic alloys; *SP640*; 1982 October. 454.

inspection; nondestructive testing; quality assurance; building materials; concrete; evaluation; inplace testing; *J. Res. 87(5)*: 407-438; 1982 September-October.

inspection agencies; laboratories; testing; ASTM committee E-36; *SP632*; 1982 March. 68-69.

inspection interval; rail flaw detection; crack detection; *SP621*; 1982 October. 69-90.

inspections; NRC; radiation measurements; regulations; regulatory guides; traceability; enforcement; *SP609*; 1982 February. 129-133.

installation; locking device classification; lock operation; characteristics; door security; entry control; hardware; *NBSIR 81-2233*.

installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; system parameters; transportable computer



software; ANSI FORTRAN; computer independent; double precision; general-purpose computer program; *TN1163*.

instrumental neutron activation analysis; precision; reference materials; standards; trace analysis; accuracy; high purity materials; *20997*.

instrumentation; irradiance; measurements; solar; temperature; fluid flow; *21349*.

instrumentation; particle size; pigment; computers; energy; *21013*.

instrumentation; photon detectors; SURF-II; calibration; electrons; *21053*.

instrumentation; pin and disc; restorative; wear; amalgam; apparatus; composite; dental; *20916*.

instrumentation amplifiers; pulse power environment; *SP628*; 1982 June. 365-377.

instrument bearing lubrication; low temperature fluidity; synthetic hydrocarbon oils; aircraft hydraulic fluid; aircraft wheel bearing grease; *SP640*; 1982 October. 348-363.

instruments; ionizing radiation; measurements; measurement support system; quality assurance; standards; traceability; calibrations; *SP609*; 1982 February. 3-10.

instruments; measurements; standards; traceability; x ray; calibration; *SP609*; 1982 February. 59-64.

insulated transmission lines; magnetic insulation; multiterawatt accelerators; particle beam fusion; peak gap voltage; voltage monitor; *SP628*; 1982 June. 80-86.

insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; *NBSIR 82-2528*.

insulation; liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; *NBSIR 82-2501*.

insulation; liquids; shock waves; breakdown; dielectrics; high voltage; *21352*.

insulation; low temperature; radiation; solid conduction; thermal conductivity; convection; foam; gas conduction; guarded-hot-plate; *NBSIR 82-1664*.

insulation; low-temperature; thermal conductivity; guarded-hot-plate apparatus; *NBSIR 81-1657*.

insulation; measurement; office-building; radiant; solar; space-heating; air-cooling; air leakage; energy; heat-recovery; *20961*.

insulation; moisture; roofing; thermal conductance; thermal conductivity; thermal resistance; built-up roofing; *21354*.

insulation; SF<sub>6</sub>; space charge; transformer oil; cables; dc fields; high voltage; incipient fault; *NBSIR 82-2586*.

insulation; space heating and cooling costs; space heating and cooling requirements; architecture; building design; cost-benefit analysis; economics; energy conservation; housing; *NBSIR 81-2380*.

integer programming; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; *20909*.

integral equations; perfect conductors; transient electromagnetic fields; wave equations; dyadic Green functions; electromagnetic scattering; *TN1157*.

integrated circuit; packages; quality control; thermal shock; Cerdip; glass sealed; *SP400-72*; 1982 April. 234-238.

integrated circuit; RTV; silicone; encapsulant; *SP400-72*; 1982 April. 275-280.

integrated circuit package; moisture; monolayer buildup; egress; ingress; *SP400-72*; 1982 April. 258-270.

integrated circuit packaging; internal water vapor; moisture evolution; package reliability; sealing glass; Cerdip; *SP400-72*; 1982 April. 220-233.

integrated circuits; aluminum-oxide interlayer; Auger; capacitance-voltage; electron devices; ellipsometric; *20827*.

integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; *SP400-74*.

integrated circuits; microelectronics; process control; process validation wafer; silicon on sapphire; test chip; test pattern; test structure; yield; *NBSIR 82-2514*.

integrated circuits; microelectronics; process control; process validation wafer; test pattern; test structure; wafer map; *20838*.

integrated circuits; microelectronic test chips; parametric testers; test methods; *20956*.

integrated circuits; moisture reliability; plastic encapsulation; surface conductivity; *SP400-72*; 1982 April. 247-257.

integrated circuits; multifunction; parametric tester; reliability; standard; test chip; test structure; custom; *20835*.

integrated design and documentation; computer maintained documentation; documentation requirements; *SP500-94*; 1982 October. 110-118.

integrated gated-diode electrometer; integrated test structure; leakage current; open-circuit voltage decay; surface recombination velocity; electrical test structure; gated diode; generation lifetime; *21143*.

integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; cost-effective; data processing; infrared spectrophotometry; *SP640*; 1982 October. 61-71.

integrated switching; packet switching survivability; alternate routing; circuit switching; communications networks; distributed control; *NBSIR 82-2588*.

integrated test structure; leakage current; open-circuit voltage decay; surface recombination velocity; electrical test structure; gated diode; generation lifetime; integrated gated-diode electrometer; *21143*.

integrated utility system; total energy systems-economic and engineering analysis; waste heat recovery; absorption chillers; boiler performance; diesel engine performance; engine-generator efficiency; *NBSIR 82-2483*.

integrating computer conferencing; management information systems; computer teleconferencing; *SP500-95*; 1982 October. 427-431.

integrating sphere spectrophotometer; reflectance; selected ordinate; solar absorber materials; solar cover plates; transmittance; weighted ordinate; air mass; ASTM E 424; *NBSIR 81-2448*.

integrity; networks; remote access of data; semantic integrity; constraint; database; database management system; data correctness; *21124*.

intelligent computer programs; knowledge engineering; machine intelligence; overview; research; state-of-the-art; applications; artificial intelligence; expert systems; forecast; funding sources; *NBSIR 82-2505*.

intense laser fields; laser induced chemistry; atomic collisions; *21116*.

intensities; interstellar molecules; microwave spectra; molecular constants; propionitrile; radio astronomy; rotational spectrum; ethanol; *JPCRD 11(2)*: 251-312; 1982.

intensities; microwave transitions; rotational transitions; absorption coefficients; carbonyl sulphide; *JPCRD 11(1)*: 101-117; 1982.

intensity dependence in infrared photochemistry; laser chemistry; laser excited fluorescence; multiphoton dissociation; unimolecular dissociation rates; CF<sub>3</sub>HCl (chlorodifluoromethane); induction times; infrared laser; *21342*.

intensity factor; notation conventions; rotational line strengths; transition moments; diatomic molecules; *21274*.

interacting multiple redox centers; interaction energies; nearest neighbor interactions; electron transfer; electron transfer model; *20837*.

interaction energies; nearest neighbor interactions; electron transfer; electron transfer model; interacting multiple redox centers; *20837*.

interactive graphics; MOS transistor; elliptic solvers; finite elements; *NBSIR 82-2471*.

interactive language; language structure; software; computer program; database; database management system; data dictionary system; data management; data standards; information resource management; *NBS-GCR-82-387*.

interactive language; language structure; software; computer program; database; database management system; data dictionary system; data management; data standards; information resource management; *NBS-GCR-82-385*.

interactive processing; random access; computer indexing; data base; directory look-up; information retrieval; *TN1167*.

interactive program development; layered architecture; time-sharing; user level workloads; Ethernet; Ethernet performance; Ethernet simulation; higher level protocols; *SP500-95*; 1982 October. 375-388.

interactive system; performance evaluation; remote terminal emulation; remote terminal emulator; system under tests; *SP500-95*; 1982 October. 409-413.

intercalated systems; lattice dynamics; phonons; two-dimensional systems; C<sub>60</sub>K; inelastic neutron scattering; *20949*.

interchangeability; law enforcement; microphone cable; mobile transceiver; performance standard; cable assembly; cable connector;



control cable; control head; D-subminiature connector; 20904.  
intercomparison; standards; thermoluminescence; calibration; dosimetry; environmental; *SP609*; 1982 February. 111-116.  
intercomparisons; measurements; radioactivity; standards; system; calibration; *SP609*; 1982 February. 31-37.  
interface; measurement; melting; metals; process control; pulse-echo technique; signal processing; solidification; ultrasonics; 21362.  
interfaces; automatic data processing (ADP); channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; input/output; *FIPS PUB 61-1*.  
interfaces; microcrystalline; nucleation; recalescence; solidification; undercooling; amorphous; cooling rate; crystalline; dendrites; 21090.  
interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; *NBSIR 81-2413*.  
interface velocity; rapid solidification; stability; surface melting; aluminum-silver alloys; cellular growth; electron beam; 21263.  
interfacial thickness; polymer; polymer interfaces; adjacent reentry; density at interface; distribution of polymer loops; 21065.  
interference; quantum mechanics; uncertainty relations; vector potential; Bohm-Aharonov; electrical transformer; 20794.  
interference source; leakage; phase measurements; power measurements; radiation pattern; TEM cell; total radiated power; dipole moments; electrically small; *TN1059*.  
interferograms, tertiary; methods, analytic; silicon; techniques, spectroscopic; FT-IR; infrared; 20828.  
interferometer; laser wavelength meter; wavemeter; Fizeau; 20862.  
interferometer; reciprocity calibration; torsional vibration; absolute measurement; accelerometer calibration; angular vibration; 20967.  
interferometric measurements; Kerr effect; Pockels effect; polarization; accuracy; calibration; electro-optical measurements; frequency response; *SP628*; 1982 June. 1-19.  
interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; *NBSIR 82-2562*.  
interior finishes; residential buildings; room fires; building fires; fire resistance; fire tests; flow measurement; gas temperatures; heat release rate; *NBSIR 80-2120*.  
interior finishes; room fires; compartment fires; correlations; corridor tests; fire growth; fire tests; flammability; flashover; *NBSIR 82-2525*.  
interlaboratory calibration; preparation techniques; aqueous standard fiber dispersions; asbestos analysis variability; fiber identification criteria; *SP619*; 1982 March. 91-107.  
interlaboratory performance; reference method; serum sodium analysis statistics; flame atomic emission spectrometry; 21206.  
interlaboratory round robin tests; thermal conductance of building sections; ASTM C-236; calibrated and guarded hot boxes; *NBSIR 81-2443*.  
interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; *SP400-74*.  
interlibrary lending; journal prices; library photocopying; publishers; book prices; copyright law; inflation; 21380.  
intermolecular interactions; molecular constants; spectral shape; collision-induced dipoles; collision-induced spectra; dielectric virial; 21167.  
internal documentation; software engineering; automated documentation; documentation standards; *SP500-94*; 1982 October. 119-125.  
internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; *TN1051*.  
internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; *Monogr. 170*.  
internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; *Monogr. 169*.  
internal friction; shear modulus; sound velocity; ultrasonic wave; Young's modulus; boron-aluminum; elastic constants; glass-epoxy; graphite-epoxy; 20868.  
internal rotation; methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; *JPCRD 11(1)*: 83-99; 1982.  
internal spaces; mixing angles; neutrino oscillations; potentials; scaling; Fermion masses; 21168.  
internal strain; laboratory testing; large scale models; mathematical model; pullout test; stress contours; concrete; crack propagation; failure surface geometry; failure theory; finite element method; *NBSIR 82-2484*.  
internal stress; neutron diffraction; nondestructive evaluation; residual stress; stress analysis; x-ray diffraction; diffraction; high-energy x-rays; 21359.  
internal viscosity; necklace model; polystyrene; Aroclor; dynamic intrinsic viscosity; 21059.  
internal water vapor; mass spectroscopy; moisture measurement; gas analysis; gases in hermetic packages; hermetic IC packages; *SP400-72*; 1982 April. 15-18.  
internal water vapor; moisture evolution; package reliability; sealing glass; Cerdip; integrated circuit packaging; *SP400-72*; 1982 April. 220-233.  
internal water vapor; moisture measurement; surface conductivity moisture monitor; gas analysis; hermetic IC packages; in-situ moisture monitor; *SP400-72*; 1982 April. 64-75.  
international; international trade; laboratory accreditation; task force; *SP632*; 1982 March. 43-45.  
international; ISO; standards; Technical Advisory Group; ASTM; building materials; fire resistance; fire tests; 21139.  
international; NVLAP system; United States; accrediting laboratories; *SP632*; 1982 March. 92-98.  
international atomic time; relativity; satellite clocks; SI second; synchronization; syntonization; time scales; coordinate time; frequency standards; 21188.  
International Electrotechnical Commission; laboratory; test facilities; certifiers; evaluation; *SP632*; 1982 March. 74-75.  
International Laboratory Accreditation Conference; international testing; laboratory accreditation; acceptance testing; accreditation systems; history; *NBSIR 82-2523*.  
International Laboratory Accreditation Conference; laboratory accreditation system; task force C; American Association for Laboratory Accreditation; *SP632*; 1982 March. 73.  
International Organization for Standardization; local area networks; National Bureau of Standards; network protocols; standards; computer networks; Federal Information Processing Standards; 21363.  
International Practical Temperature Scale of 1968; platinum resistance thermometry; fixed points; 20932.  
international quality assurance; national quality assurance; natural-matrix reference materials; radioactivity measurements; radiopharmaceuticals; traceability; environmental measurements; 20883.  
international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures; education programs; grain moisture; *SP629*.  
international standards; international test methods; national product standards; performance standards; 21163.  
International System of Units (SI); metric system; status and future; economic benefits; industry; 21120.  
international testing; laboratory accreditation; acceptance testing; accreditation systems; history; International Laboratory Accreditation Conference; *NBSIR 82-2523*.  
international test methods; national product standards; performance standards; international standards; 21163.  
international time; laser ranging; satellite; shuttle time; time and frequency metrology; time comparisons; Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; 21201.  
international time comparison; primary frequency standards; SI second; automatic time comparison; deep space network;



differential time transfer; frequency transfer; Global Positioning System; 21204.

international trade; laboratory accreditation; need; criteria; definitions; history; SP632.

international trade; laboratory accreditation; task force; international; SP632; 1982 March. 43-45.

international trading; laboratory accreditation; public; analytical laboratories; clients; SP632; 1982 March. 46-51.

interpolation; splines; approximation; clothoids; computer-aided design; Cornu-spirals; curvature; curve fitting; Fresnel-integrals; *J. Res.* 87(4): 317-346; 1982 July-August.

interstellar, molecules; line identifications; nebulae, Orion Nebula; 20923.

interstellar molecules; microwave spectra; molecular constants; propionitrile; radio astronomy; rotational spectrum; ethanol; intensities; *JPCRD* 11(2): 251-312; 1982.

interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; 21185.

interstitial space; mattresses; smoke control; smoke exhaust; smoke movement; ventilation systems; ceiling systems; hazard analysis; hospitals; *NBSIR* 81-2444.

intramolecular dynamics; laser-excited fluorescence; laser-induced chemistry; multiphoton processes; unimolecular reactions; vibrational relaxation; energy transfer; 21341.

intramolecular relaxation; laser; vibrational relaxation; hydrocarbons; 20920.

intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion; chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; 21395.

inverse gas chromatography; migration; oligomers; polyethylene; polypropylene; radiotracer; antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; *NBSIR* 82-2472.

inversion layer; Landau level; MOSFET; density of states; Hall effect; 20942.

investment strategies; oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; SP631.

iodine-125; iridium-192; radium; standards; brachytherapy; calibration; cesium-137; dosimetry standards; 21311.

iodonium compound; ionic bonding; reaction intermediate; x-ray diffraction; crystal structure; inner salt; 21268.

ion; laser-produced plasma; spectrum; strontium; vacuum ultraviolet; yttrium; 21356.

ion channeling; ion implantation; silicon; silicon dioxide; boron; dopant profile control; 20824.

ion chromatography; sulfur; cadmium sulfide; chloride-doped cadmium sulfide; chlorine; hydrogen peroxide; 20859.

ion counter; ion density; net space charge density; current density measurements; high efficiency particulate air filter; high voltage dc transmission lines; *NBSIR* 82-2527.

ion counters; ion density; ions; net space charge; corona discharge; HEPA filters; *NBSIR* 82-2486.

ion counters; ion density; measurement; net space charge; electrostatic potential; high efficiency air particulate (HEPA) filters; *NBSIR* 82-2517.

ion cyclotron resonance; ion-molecule; isomers; rate constants; reactivity; soot; 21323.

ion density; ions; net space charge; corona discharge; HEPA filters; ion counters; *NBSIR* 82-2486.

ion density; measurement; net space charge; electrostatic potential; high efficiency air particulate (HEPA) filters; ion counters; *NBSIR* 82-2517.

ion density; net space charge density; current density measurements; high efficiency particulate air filter; high voltage dc transmission lines; ion counter; *NBSIR* 82-2527.

ion dynamics; Lyman series; plasma broadening; plasma theory; relaxation theory; Stark broadening; Balmer lines; 21368.

ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; 21272.

ionic bonding; reaction intermediate; x-ray diffraction; crystal structure; inner salt; iodonium compound; 21268.

ion implant; silicon; deep-level transient spectroscopy (DLTS); defect levels; dopant profiles; furnace anneal; *NBS-GCR-81-364*.

ion implantation; laser annealing; local mode; optical spectra; phonons; Raman spectra; silicon; spectra; thermal annealing; annealing; boron; 21091.

ion implantation; ranges of application and limitations; Schottky barrier diodes; SIMS and C-V profile comparisons; automatic C-V profiler analyses; carrier depth distributions; differential capacitance-voltage profiling; SP400-71.

ion implantation; silicon; silicon dioxide; boron; dopant profile control; ion channeling; 20824.

ion-ion collision processes; multicharged ions theoretical; double resonant charge exchange; 21149.

ionisation; linear polarization; monochromatic resonance; multiphoton; perturbation theory; radiation; sodium atom; time development; transient effects; 21075.

ionization; laser excitation; resonant scattering; dense atomic vapors; electrons; 21290.

ionization; laser ionization; metal vapors; radiation trapping; resonance radiation; fluorescence; 21289.

ionization;  $Mg^{+}$ ; Na iso-sequence;  $Si^{+3}$ ;  $Al^{+3}$ ; crossed beams; cross sections; electron impact; excitation-autoionization; 21073.

ionization; multiphoton; nonresonant; atomic sodium; high power laser; 21003.

ionization; multiphoton; optogalvanic; two photons; energy transfer; flames; 21132.

ionization;  $Zn^{+}$ ; crossed beams; electron impact; excitation-autoionization;  $Ga^{+}$ ; 21071.

ionization chamber; mass; neutron beam design; neutron fission; uranium-235; 20814.

ionization chamber; photon beam; radiation therapy; absorbed dose; calibration; electron beam; high energy; 20894.

ionization chamber; water phantom; cobalt-60 gamma rays; Compton scatter; fluence scaling; graphite phantom; 21055.

ionization energy; spark; spectrum; ultraviolet; yttrium; energy level; 21240.

ionization parametric interpretation; thorium; wavelengths; actinide; energy; energy levels; 20878.

ionization potential; photoelectron spectroscopy; photoionization; spectroscopy; appearance potential; charge transfer spectrum; electron impact ionization; *NSRDS-NBS71*.

ionizing radiation; measurement; national standards; quality assurance; standard reference material; traceability; calibration; SP609; 1982 February. 45-58.

ionizing radiation; measurements; measurement support system; quality assurance; standards; traceability; calibrations; instruments; SP609; 1982 February. 3-10.

ionizing radiation; measurements; national standards; quality assurance; secondary standard laboratory; traceability; calibrations; SP609.

ionizing radiation; measurement standards; radiation dosimetry; standards; calorimeter; cavity ionization chamber; extrapolation chamber; free-air chamber; SP609; 1982 February. 29-30.

ionizing radiation; microelectronics; process-related radiation damage; radiation dose; device fabrication; electron-beam metallization; electron devices; 21184.

ionizing radiation; regulations; standards; traceability; type testing; calibrations; codes of practice; SP609; 1982 February. 19-27.

ion kinetic energy distribution; methanol; methanol-d<sub>1</sub>; methanol-d<sub>3</sub>; deuterium; electron stimulated desorption; ESD; 21133.

ion-molecule; isomers; rate constants; reactivity; soot; ion cyclotron resonance; 21323.

ion-molecule reactions; proton affinities; radicals; aromatic hydrocarbons; bond energies; 20950.

ion-molecule reactions; vibration product states; flowing afterglow; fluoride ion; infrared chemiluminescence; 20784.

ion probe; laser Raman probe; microanalysis; microscopy; electron microscopy; electron probe microanalysis; 20897.

ions; net space charge; corona discharge; HEPA filters; ion counters; ion density; *NBSIR* 82-2486.

ion-scattering spectroscopy; secondary-ion mass spectroscopy; surface analysis; x-ray photoelectron spectroscopy; Auger-electron spectroscopy; ESCA (electron spectroscopy for surface analysis); 21382.

ion storage; laser cooling; atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; 21191.

ion storage; spectroscopy; stored ion spectroscopy; atomic clock; atomic frequency standard; atomic spectroscopy; 21285.



ion trap; laser cooling; light pressure; Penning trap; quadrupole rf trap; atomic spectroscopy; 21011.

IPTS-68; magnetic thermometers; NQR thermometers; rhodium-iron thermometers; thermistors; EPT-76; germanium resistance thermometers; 20933.

iridium-192; radium; standards; brachytherapy; calibration; cesium-137; dosimetry standards; iodine-125; 21311.

iron; adsorption; chemisorption; dissociation; halocarbon; halogen; 21154.

iron; distorted wave scattering theory; electron impact ionization of ions; 20992.

iron; iron energy levels; atomic energy levels; atomic spectra; Fe; *JPCRD 11(1)*: 135-241; 1982.

iron; jet engine oil; portable; rapid; wear-metal analysis; colorimetric iron kit; *SP640*; 1982 October. 455-465.

iron; magnetism; manganese; yttrium; atomic ordering; 20866.

iron; municipal solid waste; recycling; resource recovery; standards; steel; ferrous scrap; 21358.

iron; Ni(100); carbon monoxide; catalytic activity; dissociation; hydrogen; 20987.

iron; passive films; potentiostat; anodic oxidation; dissolution of passive films; ellipsometry; 20882.

iron alloy; mass density; mechanical property; titanium alloy; alloy; aluminum alloy; elastic constants; flywheel; *NSRDS-NBS61, Part V*.

iron energy levels; atomic energy levels; atomic spectra; Fe; iron; *JPCRD 11(1)*: 135-241; 1982.

iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; 21326.

irradiance; measurements; solar; temperature; fluid flow; instrumentation; 21349.

irradiance; plasma; rare-earth; absolute; calibration; continuum; 21016.

irrigation conservation; landscaping alternatives; water conservation; water-conserving devices; faucet aerators; *SP624*; 1982 June. 53-59.

Ising ferromagnet; Padé and integral approximants; renormalization group; Boson field theory; high-temperature series expansions; hyperscaling relations; 21080.

ISO; standards; Technical Advisory Group; ASTM; building materials; fire resistance; fire tests; international; 21139.

isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; *TN1051*.

isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; *Monogr. 169*.

isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; *Monogr. 170*.

isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; *TN1051*.

isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; *Monogr. 169*.

isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; *Monogr. 170*.

isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; *TN1051*.

isoelectronic; optical properties; photoluminescence; silicon; bound exciton; density of states; indium doped silicon; 21146.

isoelectronic sequence; spectra series; vacuum ultraviolet; x rays; atomic spectra; atomic wavelengths; He-like ions; 20803.

isolated lines; neutral and ionic spectra; regularities; similarities; Stark broadening; 21365.

isomers; rate constants; reactivity; soot; ion cyclotron resonance; ion-molecule; 21323.

isomer shift; Mössbauer effect; alloying; alloy phase diagrams; charge transfer; hybridization; 20820.

isooctane; liquid separation; chrysotile asbestos; electron microscopy; filter; *SP619*; 1982 March. 85-90.

isopiestic; nickel nitrate; osmotic coefficient; solubility; solutions; thermodynamics; activity coefficient; electrolyte; excess Gibbs energy; 21234.

isopiestic; osmotic coefficient; potassium carbonate; solubility; solutions; thermodynamics; activity coefficient; electrolytes; excess Gibbs energy; 21233.

isospin splitting; isovector; Lane model; magnetic states in nuclei; 20797.

isotactic; linear macromolecule; melt; polystyrene; atactic; crystal; crystallinity; density; enthalpy; fusion; glass transition; heat capacity; *JPCRD 11(2)*: 313-325; 1982.

isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; *Monogr. 169*.

isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; *Monogr. 170*.

isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; *TN1051*.

isotope; metal hydride; neutron scattering; niobium hydride; tritide; vibration spectra; defect; 20948.

isotope dilution/mass spectrometry; mass spectrometry; stable isotope dilution analysis; statistical analysis; total cholesterol analysis; cholesterol analysis; definitive method; 20796.

isotope dilution/mass spectrometry; reference method; statistical analysis; clinical analysis; glucose in serum; glucose reference method; *SP260-80*.

isotope enrichment isotope separation; SiF<sub>4</sub> spectra; CO<sub>2</sub> saturation spectra; diode laser spectra; heterodyne spectroscopy; 21216.

isotopes; mass spectrometry; neutron activation; plasma; zinc; dietary enrichment; 21374.

isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation; activation analysis; crystal structure; diffraction; *TN1160*.

isotopic abundance; mass spectrometry; silica gel; silver; silver iodide; absolute ratios; atomic weight; Faraday constant; *J. Res. 87(1)*: 9-19; 1982 January-February.

isotopic abundances; strontium; absolute ratios; atomic weight; *J. Res. 87(1)*: 1-8; 1982 January-February.

isotopic analysis; isotopic fractionation; sample dryer; thermal ionization mass spectrometry; *TN1154*.

isotopic exchange; nickel; temperature programmed desorption; carbon monoxide; chemisorption; 20863.

isotopic fractionation; sample dryer; thermal ionization mass spectrometry; isotopic analysis; *TN1154*.

isotropic antenna; radio frequency radiation; electromagnetic field; field intensity meter; 20885.

isovector; Lane model; magnetic states in nuclei; isospin splitting; 20797.

I VII; La XI; wavelengths; Xe VIII; Ba X; Cs IX; 20815.

I(<sup>2</sup>P<sub>1/2</sub>); laser; photofragmentation; photolysis; ultraviolet; Br(<sup>2</sup>P<sub>1/2</sub>); 20785.

## J

Japan; overview; research and development; robot; state-of-the-art; applications; forecast; *NBSIR 82-2479*.

jellium; optical reflections; reflection coefficient; Riccati equation; surface reflections; wave impedance; electromagnetic waves; graded materials; inhomogeneous media; *TN1171*.



jet engine oil; portable; rapid; wear-metal analysis; colorimetric iron kit; iron; *SP640*; 1982 October. 455-465.

jet engines; monitoring; overhaul; productivity; vibration; balancing; diagnostics; faults; *SP640*; 1982 October. 115-129.

J-integral; crack opening displacement; finite element analysis; fitness-for-service; fracture mechanics; *21194*.

J-integral; low-temperature tests; stainless steels; computer-aided mechanical tests; cryogenic mechanical properties; fracture (materials); fracture toughness; *20864*.

J-integral; Si-Al-O-N; singular integral equation; crack growth model; creep cavitation; diffusive crack growth; energy release rate; high temperature fracture; *20931*.

job accounting; resource management; statistical analysis; workload characterization; capacity planning; *SP500-95*; 1982 October. 259-273.

job class; mathematical modeling; performance/modeling data acquisition; software monitor; application of basic queueing theory; IBM's RMF; *SP500-95*; 1982 October. 279-296.

joint refinement; macromolecular structures; neutron; restrained refinement; single crystals; x rays; *21136*.

joists; steel; wood; fire endurance; fire tests; flame through; floors; furnace tests; *NBSIR 82-2488*.

Josephson effect; Rh-Fe; SQUIDS; superconducting fixed points; thermometry; *21035*.

Josephson junctions; noise thermometers; nonlinear differential equation; superconductivity; *21049*.

Josephson junctions; superconductivity; supercurrent; tunneling; ac Josephson effect; dc Josephson effect; *21316*.

Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; *Monogr. 169*.

Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; *Monogr. 170*.

Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; *TN1051*.

journal prices; library photocopying; publishers; book prices; copyright law; inflation; interlibrary lending; *21380*.

journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; transactions; annual reports; diffusion in metals; fire; *NBSIR 82-2575*.

## K

KAP; metallic multilayers; reflectivity; resolving power; synchrotron radiation; 1 keV photon energy region; beryl; *21088*.

Karl Fischer reagent titration; moisture; nuclear safeguards; plutonium dioxide; water determination; automatic titration; *NBSIR 82-2496*.

Karl Fischer titration; methanol-water mixtures; solvent contraction; solvent-water mixtures; water determination; water extraction; *21277*.

KBr:CN<sup>-</sup>; KCl:CN<sup>-</sup>; neutron scattering; phonon coupling; theory; hydrogen in metals; impurity tunneling; *20879*.

KCl:CN<sup>-</sup>; neutron scattering; phonon coupling; theory; hydrogen in metals; impurity tunneling; KBr:CN<sup>-</sup>; *20879*.

Kerr effect; liquid breakdown; nitrobenzene; partial discharges; streamers; transient phenomena; electrical breakdown; high speed photography; *21328*.

Kerr effect; Pockels effect; polarization; accuracy; calibration; electro-optical measurements; frequency response; interferometric measurements; *SP628*; 1982 June. 1-19.

key volume indicator; materials logistics; business driver; *SP500-95*; 1982 October. 127-133.

key words; publications; abstracts; building technology; Center for Building Technology; *SP457-6*.

key words; publications; NBS; abstracts, NBS publications; *SP305 Supplement 13*.

kickback energy; optoelectronic measurement system; simulated kickback motion; volunteer test subjects; chain saw kickback

motion; displacement measurements; *NBSIR 82-2559*.

kilogram-size samples; municipal solid waste; refuse-derived fuel; sample characterization; sample variability; calorific value; flow calorimetry; *NBSIR 82-2491*.

kinetic isotope effect; transition state; zinc oxide; chemisorption; hydrogen; hydrogen deuterate; *20971*.

kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; review; additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; *NBSIR 82-2490*.

kinetic models; Enskog equation; hard sphere gas; *20890*.

kinetics; methylene; radicals; vinylidene; energetics; excited states; *20783*.

kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; *20955*.

kinetics; microelectronic package; moisture; moisture level; relative humidity; sorption thermodynamics; absorption; adsorption; dew point; hygrometer; *SP400-72*; 1982 April. 184-200.

kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; chromatography; copolymers; *NBSIR 81-2424*.

kinetics; polyester; polyurethane; acid; carbodiimide; degradation; hydrolysis; *20972*.

kinetics; rare gas halides; rate coefficients; excimer lasers; fluorescence branching ratios; *21299*.

kinetic study; materials science; synchrotron radiation; topography; x ray; image formation; *21257*.

kinetic theory; perturbation theory; transport coefficient; transport properties; Boltzmann equation; collision integral; *21197*.

kinetic titrimetry; ordinary differential equation solution; parabolic cylinder functions; titration; chemical kinetics solution; *20912*.

kink; tetragonal; Burgers vector; defect; dislocation; glide; inclusion; *20973*.

Kirkwood-Smoluchowski equation; liquids; nonequilibrium phenomena; nonNewtonian viscosity; statistical mechanics; *20970*.

knife-edge bearings; Mathieu's equation; single-pan balance; analytical balance; balance dynamics; balance sensitivity; balance suspension; *J. Res. 87(1): 23-45*; 1982 January-February.

knowledge-based systems; knowledge engineering; knowledge representation; problem solving; process planning; AMRF; artificial intelligence; automated manufacturing; expert systems; *NBSIR 81-2466*.

knowledge engineering; knowledge representation; problem solving; process planning; AMRF; artificial intelligence; automated manufacturing; expert systems; knowledge-based systems; *NBSIR 81-2466*.

knowledge engineering; machine intelligence; overview; research; state-of-the-art; applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; *NBSIR 82-2505*.

knowledge representation; problem solving; process planning; AMRF; artificial intelligence; automated manufacturing; expert systems; knowledge-based systems; knowledge engineering; *NBSIR 81-2466*.

Knudsen effusion; mass spectrometry; slag vaporization; transpiration; *21282*.

Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; *SP400-74*.

Kubo-Green relation; nonequilibrium dynamics; vortex viscosity; fast transport coefficients; *21238*.

K XIV; Sc XVI; Ti XVII; wavelengths; V XVIII; Ca XV; Cl XII; energy levels; *21393*.

## L

laboratories; asbestos analysis; electron microscope; error; fibrils; *SP619*; 1982 March. 162-168.

laboratories; national programs; accreditation; ILAC; *SP632*; 1982 March. 76-78.

laboratories; testing; ASTM committee E-36; inspection agencies;



- SP632; 1982 March. 68-69.  
laboratory; accreditation procedures; corporate; Corporate Standard Quality System; individual; SP632; 1982 March. 52-53.  
laboratory; legal system; standards code; testing laboratories; accreditation; SP632; 1982 March. 40-42.  
laboratory; recognition; accrediting agencies; SP632; 1982 March. 81-91.  
laboratory; test data; toxic substances; SP632; 1982 March. 79-80.  
laboratory; test facilities; certifiers; evaluation; International Electrotechnical Commission; SP632; 1982 March. 74-75.  
laboratory accreditation; acceptance testing; accreditation systems; history; International Laboratory Accreditation Conference; international testing; NBSIR 82-2523.  
laboratory accreditation; consumer interest; consumer rights; SP632; 1982 March. 65-67.  
laboratory accreditation; local; NCSBCS; state; SP632; 1982 March. 61-62.  
laboratory accreditation; manufacturing concerns; commercial; independent; SP632; 1982 March. 57-58.  
laboratory accreditation; need; criteria; definitions; history; international trade; SP632.  
laboratory accreditation; Nuclear Regulatory Commission; government operated; SP632; 1982 March. 63-64.  
laboratory accreditation; NVLAP; testing; commercial laboratories; concrete; SP632; 1982 March. 54-56.  
laboratory accreditation; product certification; system operation; accreditation; certification; functions; SP632; 1982 March. 24-27.  
laboratory accreditation; product certification program; testing laboratory; SP632; 1982 March. 70-72.  
laboratory accreditation; public; analytical laboratories; clients; international trading; SP632; 1982 March. 46-51.  
laboratory accreditation; task force; international; international trade; SP632; 1982 March. 43-45.  
laboratory accreditation; updated information; environment; SP632; 1982 March. 36-39.  
laboratory accreditation process; laboratory accreditation programs; accredited laboratories; SP636.  
laboratory accreditation programs; accredited laboratories; laboratory accreditation process; SP636.  
laboratory accreditation system; task force C; American Association for Laboratory Accreditation; International Laboratory Accreditation Conference; SP632; 1982 March. 73.  
laboratory automation; pulse analysis; pulse waveform analysis; waveform analysis; waveform recording; automated oscilloscope; computer aided measurement; SP634; 1982 June. 55-67.  
laboratory bench tests; oxidation; solubilization; automotive crankcase oils; bench test procedures; catalysts; correlation; dispersancy; engine sequence tests; hot tube; 21279.  
laboratory evaluation; accreditation; general needs; historical; SP632; 1982 March. 28-35.  
laboratory evaluation; optical method; sprayed insulation; asbestos; bulk material; SP619; 1982 March. 44-52.  
laboratory EXAFS; crystal focusing; 21008.  
laboratory test; sand; shear test; simple shear test; size effects; cyclic loading; dynamic test; 20857.  
laboratory testing; large scale models; mathematical model; pullout test; stress contours; concrete; crack propagation; failure surface geometry; failure theory; finite element method; internal strain; NBSIR 82-2484.  
laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; BSSI38.  
laboratory tests; soil moisture; soil tests; tests; thermal conductivity; thermal resistivity; Atterberg Limit tests; compaction; compaction tests; heat flow; BSSI49.  
labor problems; maintenance; management support; manpower utilization; worker productivity; breakdown maintenance; SP640; 1982 October. 495-504.  
lab procedures; Louisiana; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; NBS-GCR-81-349.  
lab procedures; Mississippi; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; NBS-GCR-81-353.  
lab procedures; model manual; monitoring; Resource Conservation and Recovery Act; State measurement needs; test protocols; analytical procedures; hazardous waste management; NBS-GCR-81-355.  
lab procedures; Oklahoma; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; NBS-GCR-81-350.  
lab procedures; Pennsylvania; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; NBS-GCR-81-351.  
lab procedures; Resource Conservation and Recovery Act; test protocols; Texas; training; analytical procedures; hazardous waste management; NBS-GCR-81-352.  
lab procedures; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; NBS-GCR-81-348.  
lab procedures; Resource Conservation and Recovery Act; test protocols; training; Virginia; analytical procedures; hazardous waste management; NBS-GCR-81-354.  
lambda doubling; laser magnetic resonance; rotational levels; Zeeman effect; CH; far infrared; hyperfine constants; 21273.  
lamellae; chain folding; crystallization of polymers; 21280.  
laminar flame; Laser Doppler Velocimeter; opposed flow; solid fuel; Damkohler number; flame spread; gas phase; heat transfer; NBS-GCR-82-388.  
laminate structure; maintenance; repairability; sandwich structure; testing; composite materials; SP640; 1982 October. 364-378.  
Lanczos algorithm; regularization; first kind integral equation; ill-posed problems; 20778.  
Lanczos smoothing; partial differential equations; stream function; vorticity; buoyant convection; finite difference computations; fire-enclosure; fluid flow; J. Res. 87(2): 165-185; 1982 March-April.  
Landau level; MOSFET; density of states; Hall effect; inversion layer; 20942.  
Landau levels; resistance standard; silicon MOSFETs; two-dimensional electron gas; fine-structure constant; Hall effect; 21220.  
landscaping alternatives; water conservation; water-conserving devices; faucet aerators; irrigation conservation; SP624; 1982 June. 53-59.  
land use planning; residential development; water conservation; SP624; 1982 June. 103-111.  
Lane model; magnetic states in nuclei; isospin splitting; isovector; 20797.  
language structure; software; computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; NBS-GCR-82-385.  
language structure; software; computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; NBS-GCR-82-387.  
language translators; portability; program inventory; RFP; statement of work; acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; SP500-90.  
large computer manufacturers; microcomputers; periodical literature and documentation; software documentation; user's groups; verbal documentation; beginning computer users; documentation; hardware systems documentation; SP500-94; 1982 October. 174-179.  
large sample, convex; regression; statistical methods; structural; errors in variable; functional; J. Res. 87(1): 67-70; 1982 January-February.  
large scale models; mathematical model; pullout test; stress contours; concrete; crack propagation; failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; NBSIR 82-2484.  
large-scale scientific computing; parallel processing; scientific workload; vector processing; Amdahl's Law; benchmarking; computing environment; SP500-95; 1982 October. 121-126.  
laser; laser-induced collisions; radiation theory; stimulated emission; atomic collisions; close-coupled scattering theory; dressed-atoms; inelastic cross-sections; 21347.  
laser; modulation; noise; acousto-optic; bandshape; bandwidth; broadening; 21375.  
laser; photodissociation; CH<sub>3</sub>; Hg(CH<sub>3</sub>)<sub>2</sub>; 21319.  
laser; photofragmentation; photolysis; ultraviolet; Br(<sup>2</sup>P<sub>1/2</sub>); I(<sup>2</sup>P<sub>1/2</sub>); 20785.  
laser; vibrational relaxation; hydrocarbons; intramolecular relaxation; 20920.  
laser ablation; laser-produced vaporization; laser-solid interaction; plasma production and heating by laser beam; pulsed-dye laser



application; resonance ionization spectroscopy; trace analysis of solids; two-photon absorption spectroscopy; 20922.

laser annealing; local mode; optical spectra; phonons; Raman spectra; silicon; spectra; thermal annealing; annealing; boron; ion implantation; 21091.

laser beam profile; mode-matching analysis; spatial filter; target designators; computer simulation; *TN1057*.

laser calibration; LNG ship tanks; photogrammetry; volume calibration; calibration accuracy; *NBSIR 81-1655*.

laser chemistry; laser excited fluorescence; molecular spectroscopy; multiphoton chemistry; carbene; hydroxyl; 21391.

laser chemistry; laser excited fluorescence; multiphoton dissociation; unimolecular dissociation rates;  $\text{CF}_3\text{HCl}$  (chlorodifluoromethane); induction times; infrared laser; intensity dependence in infrared photochemistry; 21342.

laser cooling; atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; ion storage; 21191.

laser cooling; light pressure; Penning trap; quadrupole rf trap; atomic spectroscopy; ion trap; 21011.

laser diode; laser stabilization; light shift; optical pumping; atomic frequency standard; 21210.

Laser Doppler Velocimeter; opposed flow; solid fuel; Damkohler number; flame spread; gas phase; heat transfer; laminar flame; *NBS-GCR-82-388*.

laser excitation; resonant scattering; dense atomic vapors; electrons; ionization; 21290.

laser-excited fluorescence; laser-induced chemistry; multiphoton processes; unimolecular reactions; vibrational relaxation; energy transfer; intramolecular dynamics; 21341.

laser excited fluorescence; molecular spectroscopy; multiphoton chemistry; carbene; hydroxyl; laser chemistry; 21391.

laser excited fluorescence; multiphoton dissociation; unimolecular dissociation rates;  $\text{CF}_3\text{HCl}$  (chlorodifluoromethane); induction times; infrared laser; intensity dependence in infrared photochemistry; laser chemistry; 21342.

laser frequency control; optical heterodyne spectroscopy; precision laser spectroscopy; FM spectroscopy; 21170.

laser frequency stabilization; laser spectroscopy; dye laser stabilization; 21115.

laser frequency standard; optical pumping; rubidium beam; rubidium cell; rubidium frequency standard; atomic frequency standard; 21203.

laser frequency standards; laser stability; optical frequency standards; 21001.

laser induced autoionizations; photoelectron spectra; 21281.

laser induced chemistry; atomic collisions; intense laser fields; 21116.

laser-induced chemistry; multiphoton processes; unimolecular reactions; vibrational relaxation; energy transfer; intramolecular dynamics; laser-excited fluorescence; 21341.

laser-induced collisions; radiation theory; stimulated emission; atomic collisions; close-coupled scattering theory; dressed-atoms; inelastic cross-sections; laser; 21347.

laser-induced fluorescence; polycyclic aromatic hydrocarbons; recirculation; soot formation; diffusion flames; flame stabilization; 21343.

laser ionization; metal vapors; radiation trapping; resonance radiation; fluorescence; ionization; 21289.

laser magnetic resonance; rotational levels; Zeeman effect; CH; far infrared; hyperfine constants; lambda doubling; 21273.

laser photoacoustic spectroscopy; alkanes; alkenes; C-H vibrations; 21371.

laser power meter calibration; photon flux; quantum yield; transfer standard; absolute calibration; absolute quantum yield; actinometry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; 21045.

laser-produced plasma; spectrum; strontium; vacuum ultraviolet; yttrium; ion; 21356.

laser-produced vaporization; laser-solid interaction; plasma production and heating by laser beam; pulsed-dye laser application; resonance ionization spectroscopy; trace analysis of solids; two-photon absorption spectroscopy; laser ablation; 20922.

laser Raman probe; microanalysis; microscopy; electron microscopy; electron probe microanalysis; ion probe; 20897.

laser ranging; satellite; shuttle time; time and frequency metrology; time comparisons; Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; 21201.

lasers; metrology; spectroscopy; atomic beams; cesium; frequency standards; 21252.

lasers; photoelectron spectrum; superelastic collisions; associative ionization; energy pooling; 21221.

laser-solid interaction; plasma production and heating by laser beam; pulsed-dye laser application; resonance ionization spectroscopy; trace analysis of solids; two-photon absorption spectroscopy; laser ablation; laser-produced vaporization; 20922.

laser spectroscopy; dye laser stabilization; laser frequency stabilization; 21115.

laser spectroscopy; nonlinear spectroscopy; phase conjugation; argon; 21162.

laser stability; optical frequency standards; laser frequency standards; 21001.

laser stabilization; light shift; optical pumping; atomic frequency standard; laser diode; 21210.

laser wavelength meter; wavemeter; Fizeau; interferometer; 20862.

latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; *Monogr. 169*.

latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; *Monogr. 170*.

latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; *TN1051*.

late-type stars; stars, individual; stellar atmospheres; stellar chromospheres; ultraviolet spectrum; 20816.

late-type stars; stellar atmospheres; stellar chromospheres; stellar coronae; ultraviolet spectra; 21122.

late-type stars; stellar chromospheres; stellar coronae; ultraviolet spectra; flare stars; 21405.

lattice constant of yttrium-doped cerium dioxide; carbonates, cerium-yttrium, coprecipitation of; ceramics, ceria-yttria, high-density; ceramics, ceria-yttria, hot-pressing of; cerium dioxide, yttrium-doped; cerium-yttrium oxide ceramic; cerium-yttrium oxide powders; homogeneous solution, precipitation from; 21051.

lattice constants; powder patterns; reference intensities; standard; x-ray diffraction; crystal structure; densities; *Monogr. 25, Section 19*.

lattice dynamics; lithium; molecular dynamics; rubidium; anharmonic effects; Debye-Waller factor; 21096.

lattice dynamics; phonons; two-dimensional systems;  $\text{C}_{36}\text{K}$ ; inelastic neutron scattering; intercalated systems; 20949.

lattice random walk; mean occupation time; polymer adsorption; probability of first return; restricted random walk; absorbing points; 20826.

law enforcement; microphone cable; mobile transceiver; performance standard; cable assembly; cable connector; control cable; control head; D-subminiature connector; interchangeability; 20904.

law enforcement; mobile digital terminals; voice message traffic; digital communications equipment; digital techniques; equipment standards; *NBS-GCR-81-356*.

law enforcement; performance standard; radiation pattern; relative antenna gain; antenna; base station; fixed antennas; 20901.

law enforcement; performance test methods; emergency vehicle sirens; environmental tests; 20919.

law enforcement standard; selective signaling; squelch systems; tone-coding; decoder; digital controlled; encoder; 20991.

La XI; wavelengths; Xe VIII; Ba X; Cs IX; I VII; 20815.

layered architecture; time-sharing; user level workloads; Ethernet; Ethernet performance; Ethernet simulation; higher level protocols; interactive program development; *SP500-95*; 1982 October. 375-388.

LC oscillator; oscillator sensor; pressure; pulsed oscillator; pulsed sensor; temperature; tunnel diode; tunnel diode oscillator; 21064.

leachables; mammary prosthesis; polymeric implants; prolyl hydroxylase; enzymatic assay; gas chromatography/mass spectrometry; *NBSIR 81-2436*.

leachates; leach testing; nuclear waste; trace elements. nuclear waste; trace elements; chemical blank; contamination control; 21372.

leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; speciation; arsenic; atomic absorption; environment; fingerprint; 21125.



- leaching; nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; 21272.
- leach testing; nuclear waste; trace elements. nuclear waste; trace elements; chemical blank; contamination control; leachates; 21372.
- lead; measurement methods; measurement systems; standard reference materials (SRM's); industrial atmosphere; SP619; 1982 March. 29-33.
- leakage; life safety; smoke; smoke movement; stack effects; test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; 21121.
- leakage; phase measurements; power measurements; radiation pattern; TEM cell; total radiated power; dipole moments; electrically small; interference source; TN1059.
- leakage current; capacitance; cooling rate; dew point; SP400-72; 1982 April. 98-104.
- leakage current; open-circuit voltage decay; surface recombination velocity; electrical test structure; gated diode; generation lifetime; integrated gated-diode electrometer; integrated test structure; 21143.
- leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; and ultrasonics; acoustic emission; eddy currents; imaging; NBSIR 82-2449.
- leak detection; mass spectrometry; Method 1018; moisture sensors; surface conductivity sensors; aluminum oxide sensors; Cerdisp; Cerpak; SP400-72; 1982 April. 90-97.
- leak detection; preventive maintenance; rental apartment complexes; waste flow; water conservation; watersaving devices; controlled installation; SP624; 1982 June. 169-171.
- leak rate measurements; liquid penetrants; magnetic particles; neutron radiography; traceable NDE; visual acuity; acoustic emission; eddy currents; 21166.
- leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; radiography; standards; traceable measurements; visual testing; acoustic emission; calibration; 21398.
- leak test; methanol; silicone coating; UV light; hermeticity; hybrid; SP400-72; 1982 April. 271-274.
- leak testing; back pressurization; electronic packages; hermetic test; SP400-73.
- leak testing; back pressurization; electronic packages; hermetic test; 20856.
- leak vs. break; part-through crack; pipeline fracture; plastic necking instability; progressive crack growth; crack initiation; crack opening displacement; ductile fracture; SP621; 1982 October. 153-164.
- legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; SP629.
- legal system; standards code; testing laboratories; accreditation; laboratory; SP632; 1982 March. 40-42.
- length-measuring devices; liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; user requirements; volume-measuring devices; weights; H44.
- Lennard-Jones fluid; nonequilibrium molecular dynamics; nonlinear phenomena; phase changes; stability criteria; thermodynamics of the steady state; computer simulation; Couette flow; 20959.
- Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; 20836.
- leucocyanines; pulse radiolysis; radiation processing; radiochromic dyes; bleaching of dyes; dose rate; dosimetry; dyes; film dosimetry; gamma rays; humidity effects; 20844.
- leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosalaniline; 20905.
- leuko cyanides; neutron dosimetry; optical waveguides; radiochromic dyes; anomalous dispersion; dimethyl sulfoxide; dosimetry; fibre optics; gamma-ray dosimetry; 20804.
- levitation calorimetry; segregation; specific heat; surface tension; thermophysical properties; tungsten; Auger spectroscopy; convection; gallium-tin alloys; NBSIR 82-2560.
- library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; transactions; annual reports; diffusion in metals; fire; journals; NBSIR 82-2575.
- library photocopying; publishers; book prices; copyright law; inflation; interlibrary lending; journal prices; 21380.
- Lie algebra; nonlinear oscillations; normalization; representation theory; generalized inverses; Hamiltonian mechanics; NBSIR 82-2541.
- life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; SP640; 1982 October. 257-274.
- life-cycle; software; specifications; standards; documentation; guidelines; SP500-87.
- life cycle cost; Life Safety Code; automatic sprinklers; building codes; building construction; health care facilities; NBSIR 82-2558.
- life-cycle cost analysis; net savings; solar energy computer program; solar energy economics; solar energy systems; computer simulation models; Federal Life-Cycle Cost Rules; NBSIR 81-2379.
- life-cycle costing; solar energy; building economics; commercial buildings; economic analysis; energy economics; NBSIR 82-2540.
- life-cycle costs; benefit-cost analysis; energy conservation; equipment selection; equipment sizing; heat pump; NBSIR 80-2176.
- life cycle costs; maintenance; track; Simulation Cost Model; track maintenance planning; track standards; computer simulation; SP640; 1982 October. 199-215.
- life cycle management; long-range planning; systems planning and control; ADP planning; Federal ADP procurement; SP500-95; 1982 October. 11-18.
- life-cycle management; quantitative forecasting techniques; workload forecasting; SP500-95; 1982 October. 435.
- life data; life distribution; reliability; service life; wood; durability; duration of load; 20809.
- life distribution; reliability; service life; wood; durability; duration of load; life data; 20809.
- life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; NBS-GCR-82-383.
- life safety; room fires; sidewall sprinkler systems; thermal response; automatic sprinklers; compartment fires; fire safety; NBSIR 82-2521.
- life safety; smoke; smoke movement; stack effects; test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; 21121.
- Life Safety Code; automatic sprinklers; building codes; building construction; health care facilities; life cycle cost; NBSIR 82-2558.
- Life Safety Code; means of egress; emergency egress; fire protection; fire safety; human behavior in fires; human factors; NBSIR 82-2480.
- Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; NBSIR 82-2562.
- lifetime; polarization;  $Zn^{+}$ ; crossed beams; cross sections; electron impact excitation; 21072.
- lifetime; power-device grade silicon; transient capacitance techniques; deep-level measurements; deep-level transient spectroscopy; defect characterization; NBSIR 82-2552.
- lighting energy; task lighting; building energy performance; building subsystem energy criteria; energy conservation in lighting; general lighting; illumination energy; 21042.
- light pressure; Penning trap; quadrupole rf trap; atomic spectroscopy; ion trap; laser cooling; 21011.
- light scattering; critical phenomena in space; critical point; dielectric constant; gravity effects; 20875.
- light scattering; liquid droplets; microspheres; Mie theory; optical levitation; particle sizing; polarization ratio; radiation pressure; resonances; 21054.
- light scattering; magnetic alignment; magnetic filtration; rapid fiber analysis; asbestos fibers; SP619; 1982 March. 108-120.
- light shift; optical pumping; atomic frequency standard; laser diode; laser stabilization; 21210.
- linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; IC photomask; TN1164.
- linearity; metrology support; phase angle calibration; signal sampling;



stability; waveform synthesis; ac-dc difference; data conversion; dynamic response; 21027.

linear macromolecule; melt; polystyrene; atactic; crystal; crystallinity; density; enthalpy; fusion; glass transition; heat capacity; isotactic; *JPCRD 11(2)*: 313-325; 1982.

linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid); enthalpy; entropy; glass transition; heat capacity; *JPCRD 11(4)*: 1065-1089; 1982.

linear models; minimax; peak area; smoothing; spectroscopy; splines; statistical methods; *J. Res. 87(1)*: 53-65; 1982 January-February.

linear polarization; monochromatic resonance; multiphoton; perturbation theory; radiation; sodium atom; time development; transient effects; ionisation; 21075.

linear regression; neutron diffraction; powder refinement; significant differences; statistical analysis; comparison of models; 21401.

line broadening; model microfield; plasma; Stark; strong collisions; 20846.

line broadening; nitrogen; sodium; 20871.

line formation; line profiles; radiative transfer; 20938.

line formation; masers; stars, circumstellar shells; 21033.

line identifications; nebulae, Orion Nebula; interstellar, molecules; 20923.

line profiles; radiative transfer; line formation; 20938.

line replaceable units; malfunction; microprocessor controlled test set; symptom; test strategy; automated test equipment; fault isolation diagnostics; functional subsystem; *SP640*; 1982 October. 223-234.

lineshape; radiative transfer; spectral line formation; stellar atmospheres; Voigt function; 21148.

line shape; rare gas mixtures; spectra; transient dipoles; collision-induced absorption; collision-induced light scattering; far infrared absorption; induced dipole; 21173.

line-spacing; linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; IC photomask; linear calibration curve; *TN1164*.

line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; *SP400-74*.

linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; IC photomask; linear calibration curve; line-spacing; *TN1164*.

linewidth; microelectronic test structure; process control; sheet resistance; test structure; cross-bridge structure; *NBSIR 82-2548*.

linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; *SP400-74*.

linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; *SP400-74*.

liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; *BSS138*.

liquefaction of helium; mechanical equivalence; mixtures; molecular potential; quantum parameter; corresponding states; critical point universality; 20899.

liquefied natural gas; computational methods; computer programs; custody transfer; density measurement; density reference standard; 20946.

liquefied natural gas; methane; densimeter; density; *TN1055*.

liquid; propane; thermal conductivity; transient hot wire; 20831.

liquid breakdown; nitrobenzene; partial discharges; streamers; transient phenomena; electrical breakdown; high speed photography; Kerr effect; 21328.

liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; *NBSIR 82-2501*.

liquid breakdown; SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; *NBSIR 82-2528*.

liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; speciation; arsenic; atomic absorption; environment; fingerprint; leaching; 21125.

liquid crystals; polycyclic aromatic hydrocarbons; wall-coated open-tubular columns; gas-liquid chromatography; 20965.

liquid density; mixtures; second virial coefficients; vapor-liquid equilibrium; vapor pressure; volume change of mixing; equations of state; heat of mixing; *JPCRD 11(3)*: 941-951; 1982.

liquid droplets; microspheres; Mie theory; optical levitation; particle sizing; polarization ratio; radiation pressure; resonances; light scattering; 21054.

liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; gamma radiation; 20902.

liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; user requirements; volume-measuring devices; weights; length-measuring devices; *H44*.

liquid membrane; membrane; purification; separation; chemical engineering; facilitated transport; 21241.

liquid natural gas; coordinate transformation; custody transfer; energy; 21324.

liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; radiography; tire inspection; ultrasonics; visual-optical; acoustic emission; eddy currents; 20957.

liquid penetrants; magnetic particles; neutron radiography; traceable NDE; visual acuity; acoustic emission; eddy currents; leak rate measurements; 21166.

liquid penetrants; magnetic particles; nondestructive evaluation; radiography; standards; traceable measurements; visual testing; acoustic emission; calibration; leak rate measurements; 21398.

liquid pool fires; thermoplastic pool fires; wood crib fires; compartment fires; fire endurance; fire engineering design; 21093.

liquids; nonequilibrium phenomena; nonNewtonian viscosity; statistical mechanics; Kirkwood-Smoluchowski equation; 20970.

liquids; partial discharge; polydimethylsiloxanes; breakdown; electrical insulation; high voltage; 21130.

liquids; shock waves; breakdown; dielectrics; high voltage; insulation; 21352.

liquid-scintillation counting; plutonium-239 (half life); plutonium isotopic abundances; radioactive decay; alpha-particle-emission rates; 21246.

liquid separation; chrysotile asbestos; electron microscopy; filter; isooctane; *SP619*; 1982 March. 85-90.

liquid <sup>3</sup>He; superconductivity; temperature; transition temperature; tungsten; beryllium; fixed points; 21063.

literature reviews; radiant energy; stoves; wall protection; walls; wood; chimneys; fire tests; flues; heating equipment; *NBSIR 82-2506*.

lithium; molecular dynamics; rubidium; anharmonic effects; Debye-Waller factor; lattice dynamics; 21096.

lithium atom; electron-atom scattering; electron impact ionization; *J. Res. 87(1)*: 49-51; 1982 January-February.

lithium borate; lyoluminescence; radiochromic dye; alanine; biographic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; 20889.

lithium tantalate; neutron diffraction; powder method; Rietveld method; solid solution; tantalum oxide; 21157.

lithography; photoresists; synchrotron radiation; energy deposition; extreme ultraviolet; high resolution; 21078.

LNG ship tanks; photogrammetry; volume calibration; calibration accuracy; laser calibration; *NBSIR 81-1655*.

load capacity; mobile homes; soil anchors; soil mechanics; stiffness; wind forces; anchors; cyclic loading; field testing; flood forces; foundations; *BSS142*.

load cell; mass comparator; substitution weighing; weighing; constant loading; high precision; *J. Res. 87(1)*: 47-48; 1982 January-February.

load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; throughput; transition matrix; carrier sense multiple access; channel access; *SP500-95*; 1982 October. 365-373.

load-displacement characteristics; power-law crack growth; ceramic fracture test; crack growth of ceramics; four-point bend test; fracture test; initial value problem; *NBSIR 82-2504*.

local; microprocessor; network; serial; broadcast; coaxial;



communication; contention; data; digital; Ethernet; 20839.

local; NCSBCS; state; laboratory accreditation; *SP632*; 1982 March. 61-62.

local area network; computer performance modeling; computer simulation; *SP500-95*; 1982 October. 107.

local area networks; local network specification; requirements analysis; feature analysis; guidelines; *SP500-96*.

local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; throughput; transition matrix; carrier sense multiple access; channel access; load dependent; *SP500-95*; 1982 October. 365-373.

local area networks; National Bureau of Standards; network protocols; standards; computer networks; Federal Information Processing Standards; International Organization for Standardization; 21363.

local derailment; nitinol sensor; on-board failure detection system; overheated bearings; thermal switch sensor; train line; contact derailment sensor; g-sensing derailment detector; *SP621*; 1982 October. 49-68.

localized corrosion; localized corrosion mechanism; pitting; accelerated testing; crevice corrosion; electrochemical techniques; *NBSIR 82-2477*.

localized corrosion; surface model; corrosion of an IC; IC surface; *SP400-72*; 1982 April. 129-148.

localized corrosion mechanism; pitting; accelerated testing; crevice corrosion; electrochemical techniques; localized corrosion; *NBSIR 82-2477*.

local mode; optical spectra; phonons; Raman spectra; silicon; spectra; thermal annealing; annealing; boron; ion implantation; laser annealing; 21091.

local networking; mathematical modeling; measurement; network performance; performance evaluation; computer network; *SP500-95*; 1982 October. 389-396.

local network specification; requirements analysis; feature analysis; guidelines; local area networks; *SP500-96*.

lock; queue; simulation; waiting time; capacity; dam; *NBSIR 81-2411*.

locking device classification; lock operation; characteristics; door security; entry control; hardware; installation; *NBSIR 81-2233*.

lock operation; characteristics; door security; entry control; hardware; installation; locking device classification; *NBSIR 81-2233*.

logical database design; logical database design tools; schema design; database design; database design tools; database management; *NBS-GCR-82-389*.

logical database design; network data model; relational data model; schema design; database design; database management; database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; *NBS-GCR-82-390*.

logical database design tools; schema design; database design; database design tools; database management; logical database design; *NBS-GCR-82-389*.

lognormal; small-scale turbulence; velocity gradients; higher-order moments; hot-wire anemometry; 21278.

long life; reduced maintenance; silicone brake fluid; U.S. Army; *SP640*; 1982 October. 162-169.

long-lived-mixed radionuclide standard; uncertainties in gamma-ray measurements; calibration of gamma-ray detector efficiencies; emission-rate measurements; gamma-ray spectrometry; germanium-detector efficiencies; 20874.

long-range planning; systems planning and control; ADP planning; Federal ADP procurement; life cycle management; *SP500-95*; 1982 October. 11-18.

loopless graph; partition; degree sequence; graph; incidence sequence; *J. Res. 87(1)*: 75-78; 1982 January-February.

loops; polymer; semicrystalline polymer; tie molecules; amorphous phase; crystal-amorphous interface; fold surface; 21159.

Lorentz transformation; special relativity; plasma charge conservation; transient propagation; arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; 21327.

Louisiana; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-349*.

low-density mineral fiber; thermal conductivity; thermal resistance; thickness effect; building insulation; energy conservation; guarded hot plate; heat flow meter; heat transfer; *NBSIR 82-2538*.

low density polyethylene; plastic deformation; sorbate concentration; sorption; weight gain; concentration coefficient of diffusivity; density; diffusion coefficient; drawing stress; 20876.

low energy electron diffraction; thermal desorption; adsorption; carbon monoxide on Ni(111); electron stimulated desorption; *ESDIAD*; 21100.

lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; units; data reporting; detection limit; environmental; 20888.

low flows; plumbing products; appliances; fittings; fixtures; *SP624*; 1982 June. 289-292.

low-level counting; radiocarbon; accelerator mass spectrometry; atmospheric pollution; carbonaceous gases and particles; carbon cycle; chemical selectivity; climate; 21041.

low-level laser measurements; modulated cw measurement system; PIN transfer standards; pulse energy; pulse peak power; 1.064  $\mu\text{m}$  laser pulse measurements; APD transfer standards; beamsplitter attenuator; impulse response measurements; *TN1058*.

low-Q chambers; reverberation chambers; transverse electromagnetic cells; buried electromagnetic enclosures; electromagnetic compatibility measurements (EMC); 21061.

low temperature; magnetic spin structure; nuclear magnetism; nuclear orientation;  $\gamma$  rays;  $^{166\text{m}}\text{Ho}$ - $^{166}\text{Ho}$  atomic magnetism; helical spin structure; holmium single crystal; 21017.

low-temperature; magnetic transition; physical properties; Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; 21198.

low temperature; maximum strength; mechanical properties; yield strength; Young's modulus; compressive strength; concrete mortar; elongation; *NBSIR 82-1658*.

low temperature; radiation; solid conduction; thermal conductivity; convection; foam; gas conduction; guarded-hot-plate; insulation; *NBSIR 82-1664*.

low temperature; refrigerator; Stirling cycle; superconducting devices; cryocooler; cryogenics; *TN1049*.

low-temperature; standard; superconductor; critical current; critical temperature; electrical property; 21014.

low-temperature; thermal conductivity; guarded-hot-plate apparatus; insulation; *NBSIR 81-1657*.

low temperature fluidity; synthetic hydrocarbon oils; aircraft hydraulic fluid; aircraft wheel bearing grease; instrument bearing lubrication; *SP640*; 1982 October. 348-363.

low-temperature gases; noise thermometry; nuclear orientation thermometry; superconductors; temperature fixed points; thermodynamic temperature; thermometry; tunnel diode oscillators; 21018.

low temperature spectrum; torsional splittings; C-H stretching region; difference-frequency laser; Doppler-limited resolution; ethane; ground state constants; infrared spectrum; *J. Res. 87(3)*: 237-256; 1982 May-June.

low-temperature tests; stainless steels; computer-aided mechanical tests; cryogenic mechanical properties; fracture (materials); fracture toughness; J-integral; 20864.

low water usage devices; pitch of the pipe; plumbing drainage system; plumbing fixtures; transport mechanisms; transport phenomena; wall friction; building pipe drains; *SP624*; 1982 June. 293-326.

low-water-using bathroom fixtures; residential water savings; retrofitting; water conservation device; *SP624*; 1982 June. 329-337.

LSI circuits; mass spectrometry; on-going monitoring activity; package-sealing environment; aluminum oxide; Cerdip packages; IC assembly; in-situ moisture sensors; *SP400-72*; 1982 April. 113-116.

lubricant additive; solid lubricant; wear; wear debris; antimony thioantimonate; electron microscopy; *NBSIR 82-2545*.

lubricant displacement; precision instrument bearings; antistat-bearing steel interaction; antistatic agents; antistat-lubricant interaction; bearing packaging materials; bearing steel wettability; *SP640*; 1982 October. 290-294.

lubricants; oil recycling; petroleum; pollution control; reclaiming; re-refining; used oil; waste oil; 21383.

lubricating oil; lubricating oil analysis; lubricating testing; petroleum; petroleum testing; recycled oil; re-refining; used oil recycling; additive response; lubricating oil bench tests; 21397.

lubricating oil; motor oil; petroleum oil; recycled oil; re-refined oil; test procedures; basestock; engine lubricants; 20990.

lubricating oil analysis; lubricating testing; petroleum; petroleum testing; recycled oil; re-refining; used oil recycling; additive response; lubricating oil bench tests; lubricating oil; 21397.

lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; petroleum; petroleum testing; recycled oil; re-refining; used oil recycling; additive response; 21397.



lubricating oils; materials testing; oxidation; petroleum products; review; additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; *NBSIR 82-2490*.

lubricating testing; petroleum; petroleum testing; recycled oil; re-refining; used oil recycling; additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; *21397*.

lubrication; maintenance; maintenance management; maintenance technology; manpower utilization; reliability assessment; fault detection/location system; *SP640*.

lubrication systems; maintenance program; prevention; diagnostic controls; hydro-dynamic condition; *SP640*; 1982 October. 170-186.

luminescence; melts; oxidation; reduction; terbium; glass; *21315*.

lunar theory; satellite theory; celestial mechanics; Fourier series; *21030*.

Lyman series; plasma broadening; plasma theory; relaxation theory; Stark broadening; Balmer lines; ion dynamics; *21368*.

lyoluminescence; radiochromic dye; alanine; biologicraphic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; *20889*.

## M

machine intelligence; overview; research; state-of-the-art; applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; *NBSIR 82-2505*.

machine-readable; text formatters; data documentation; *SP500-94*; 1982 October. 203-208.

machine-readable cataloging; machine-readable data files; MARC; MRDF; numeric data files; software summary; ANSI Z39.2; bibliographic control; FIPS 30; format structure; *SP500-94*; 1982 October. 189-196.

machine-readable data files; MARC; MRDF; numeric data files; software summary; ANSI Z39.2; bibliographic control; FIPS 30; format structure; machine-readable cataloging; *SP500-94*; 1982 October. 189-196.

machine-readable data files (MRDF); bibliographic control; bibliographic standards; computer software; documentation standards; *SP500-94*; 1982 October. 183-188.

machines; stress systems; tension loading; brittle materials; ductile materials; fatigue; fractures; *SP621*; 1982 October. 196-200.

macro-molecular clustering; molybdenum disulphide imbedment; carbide precipitation; decarburization zones; implantment by mechanical inclusion; *SP640*; 1982 October. 187-193.

macromolecular crystallography; neutrons; position-sensitive detectors; precision of data; x rays; diffractometry; *20982*.

macromolecular structures; neutron; restrained refinement; single crystals; x rays; joint refinement; *21136*.

magnesium arsenate hydrate; magnesium phosphate hydrate; struvite analogue; water-rich hydrates; crystal structure; hydration of  $\text{XO}_4$  ion; *20873*.

magnesium phosphate hydrate; struvite analogue; water-rich hydrates; crystal structure; hydration of  $\text{XO}_4$  ion; magnesium arsenate hydrate; *20873*.

magnetic alignment; magnetic filtration; rapid fiber analysis; asbestos fibers; light scattering; *SP619*; 1982 March. 108-120.

magnetic dipole; Rosenbluth separation; 10.3 MeV transition;  $^{40}\text{Ca}$ ; form factor; ground state transition width; inelastic electron scattering; *21037*.

magnetic field; measurement; niobium; superconductor; tin; titanium; copper; critical current; electrical property; *21218*.

magnetic filtration; rapid fiber analysis; asbestos fibers; light scattering; magnetic alignment; *SP619*; 1982 March. 108-120.

magnetic ink characters; MICR; MICR Read Optically; OCR; optical character recognition; character shapes; data entry; Federal Information Processing Standard; graphic shapes; *FIPS PUB 32-1*.

magnetic insulating voltage measurement; negative ions; Thomson Parabola charged particle analyser; *SP628*; 1982 June. 87-94.

magnetic insulation; multiterawatt accelerators; particle beam fusion; peak gap voltage; voltage monitor; insulated transmission lines; *SP628*; 1982 June. 80-86.

magnetic particles; microwaves; nondestructive evaluation; radiography; tire inspection; ultrasonics; visual-optical; acoustic emission; eddy currents; liquid penetrants; *20957*.

magnetic particles; neutron radiography; traceable NDE; visual acuity; acoustic emission; eddy currents; leak rate measurements;

liquid penetrants; *21166*.

magnetic particles; nondestructive evaluation; radiography; standards; traceable measurements; visual testing; acoustic emission; calibration; leak rate measurements; liquid penetrants; *21398*.

magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; and ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; *NBSIR 82-2449*.

magnetic spin structure; nuclear magnetism; nuclear orientation;  $\gamma$  rays;  $^{166\text{m}}\text{Ho}$ -Ho atomic magnetism; helical spin structure; holmium single crystal; low temperature; *21017*.

magnetic states in nuclei; isospin splitting; isovector; Lane model; *20797*.

magnetic susceptibility; magnetoresistivity; superconductor; *21015*.

magnetic suspension; capacitance sensing; electronic balance; feedback control; fluid density; hydrostatic weighing; *21207*.

magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; *FIPS PUB 93*.

magnetic tape cassettes; magnetic tape recording; magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; *FIPS PUB 91*.

magnetic tape recording; magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cassettes; *FIPS PUB 91*.

magnetic tape recordings; magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cartridge; *FIPS PUB 93*.

magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cassettes; magnetic tape recording; *FIPS PUB 91*.

magnetic tape transports; standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cartridge; magnetic tape recordings; *FIPS PUB 93*.

magnetic tape units; terminals; disk units; Federal Government computers; Federal minicomputers; Federal statistics; general purpose computers; *SP500-97*.

magnetic thermometers; NQR thermometers; rhodium-iron thermometers; thermistors; EPT-76; germanium resistance thermometers; IPTS-68; *20933*.

magnetic transition; physical properties; Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; low-temperature; *21198*.

magnetism; manganese; yttrium; atomic ordering; iron; *20866*.

magnetization; neutron diffraction; spin waves; transition metals; amorphous materials; ferromagnetism; *20945*.

magnetoresistivity; superconductor; magnetic susceptibility; *21015*.

main atomic peak; microwave power level changes; servo; sidelobe atomic peak; atomic clock; atomic resonance frequency error; fixed offset frequency; *U.S. Patent 4,331,933*.

main memory contention; modeling; packet switch; performance evaluation; simulation; trunk; WIN; analytical; capacity planning; central server; disk; *SP500-95*; 1982 October. 97-106.

maintenance; maintenance costs; maintenance technology; technology centers; technology innovation; *SP640*; 1982 October. 17-26.

maintenance; maintenance management; maintenance technology; manpower utilization; reliability assessment; fault detection/location system; lubrication; *SP640*.

maintenance; management support; manpower utilization; worker productivity; breakdown maintenance; labor problems; *SP640*; 1982 October. 495-504.

maintenance; reparability; sandwich structure; testing; composite materials; laminate structure; *SP640*; 1982 October. 364-378.

maintenance costs; maintenance technology; technology centers; technology innovation; maintenance; *SP640*; 1982 October. 17-26.

maintenance effectiveness; preventive maintenance plan; programmed inspections; cost effectiveness; *SP640*; 1982 October. 86-112.

maintenance information systems functions; management and financial functions; master planning; material and logistics functions; personnel/component/support shop functions; powerplant/component/support shop functions; aircraft maintenance functions; *SP640*; 1982 October. 27-44.

maintenance (inspection) interval; engineering failure mode; failure;



failure analysis; failure modes and effects analysis; *SP640*; 1982 October. 45-60.

maintenance management; maintenance technology; manpower utilization; reliability assessment; fault detection/location system; lubrication; maintenance; *SP640*.

maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; cost-effective; data processing; infrared spectrophotometry; integrated reporting system; *SP640*; 1982 October. 61-71.

maintenance program; prevention; diagnostic controls; hydro-dynamic condition; lubrication systems; *SP640*; 1982 October. 170-186.

maintenance technology; manpower utilization; reliability assessment; fault detection/location system; lubrication; maintenance; maintenance management; *SP640*.

maintenance technology; technology centers; technology innovation; maintenance; maintenance costs; *SP640*; 1982 October. 17-26.

maintenance, track; Simulation Cost Model; track maintenance planning; track standards; computer simulation; life cycle costs; *SP640*; 1982 October. 199-215.

major costs; wastewater treatment; water conservation; water-saving devices; *SP624*; 1982 June. 227-238.

majorization; median; statistical methods; concave; convex; inequality; *J. Res. 87(1)*: 71-74; 1982 January-February.

malfuction; microprocessor controlled test set; symptom; test strategy; automated test equipment; fault isolation diagnostics; functional subsystem; line replaceable units; *SP640*; 1982 October. 223-234.

mammary prosthesis; polymeric implants; prolyl hydroxylase; enzymatic assay; gas chromatography/mass spectrometry; leachables; *NBSIR 81-2436*.

management and financial functions; master planning; material and logistics functions; personnel/component/support shop functions; powerplant/component/support shop functions; aircraft maintenance functions; maintenance information systems functions; *SP640*; 1982 October. 27-44.

management information systems; computer tele/conferencing; integrating computer conferencing; *SP500-95*; 1982 October. 427-431.

management options; document types; DoD standard; *SP500-94*; 1982 October. 152-156.

management support; manpower utilization; worker productivity; breakdown maintenance; labor problems; maintenance; *SP640*; 1982 October. 495-504.

management-tool; methodologies; strategies; techniques; concepts; Information Resource Management; Information Systems Management; *SP500-95*; 1982 October. 5-9.

mandatory requirements; optional requirements; procurement; relational; standards; database management; DBMS; functional specification; *NBS-GCR-82-372*.

manganese; yttrium; atomic ordering; iron; magnetism; *20866*.

manganese compounds; neutron diffraction; profile refinement; rare earths; crystal fields; ferromagnetism; *20944*.

manpower utilization; reliability assessment; fault detection/location system; lubrication; maintenance; maintenance management; maintenance technology; *SP640*.

manpower utilization; worker productivity; breakdown maintenance; labor problems; maintenance; management support; *SP640*; 1982 October. 495-504.

manufacturer; tractor model; exporting; governmental regulations; *SP632*; 1982 March. 59-60.

manufacturing concerns; commercial; independent; laboratory accreditation; *SP632*; 1982 March. 57-58.

manufacturing research; research facility; automated machining; hierarchical control; *21378*.

many-body theory; photoemission; relaxation; adsorption; *21151*.

MARC; MRDF; numeric data files; software summary; ANSI Z39.2; bibliographic control; FIPS 30; format structure; machine-readable cataloging; machine-readable data files; *SP500-94*; 1982 October. 189-196.

marginal price; water conservation; water pricing; water rate schedules; average price; economic analysis; *21142*.

marine environmental factors; moisture intrusion in avionic equipment; avionic component design; avionic corrosion damage; corrosion damage; equipment design failures; *SP640*; 1982 October. 379-399.

marine environments; salt fog; alternate immersion; corrosivity monitoring device; exposure tests; *SP640*; 1982 October. 476-494.

Marx erection time; Marx generators; Remote Command Data Link; EMP simulator; *SP628*; 1982 June. 316-319.

Marx generators; Remote Command Data Link; electromagnetic pulse; fiber optics; *SP628*; 1982 June. 310-315.

Marx generators; Remote Command Data Link; EMP simulator; Marx erection time; *SP628*; 1982 June. 316-319.

masers; stars, circumstellar shells; line formation; *21033*.

mass; neutron beam design; neutron fission; uranium-235; ionization chamber; *20814*.

mass comparator; substitution weighing; weighing; constant loading; high precision; load cell; *J. Res. 87(1)*: 47-48; 1982 January-February.

mass concentrations; water samples; chrysotile asbestos; fiber; glass; *SP619*; 1982 March. 121-131.

mass density; mechanical property; titanium alloy; alloy; aluminum alloy; elastic constants; flywheel; iron alloy; *NSRDS-NBS61, Part V*.

mass exchange; RS Canum Venaticorum binaries; spectrophotometry; stars, individual; symbiotic stars; *20808*.

mass formula; nuclear shell effects; quartetting; supermultiplets; atomic masses; binding energies; *20939*.

mass loss; test methods; calorimeters; correlation; energy transfer; fire tests; flame spread; ignition; *NBSIR 82-2536*.

mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; moisture measurement; three volume calibration valve; three volume calibrator; water-vapor measurement; *SP400-72*; 1982 April. 8-14.

mass spectrometer; moisture measurement; oxygen; software; sorption; water; algorithms; calibration; chemical reactions; gas flow; gas transfer; *SP400-72*; 1982 April. 3-7.

mass spectrometer; seam sealing; sensor chips; standards; water vapor; dew point; hermetic packages; *SP400-72*; 1982 April. 49-63.

mass spectrometer; SF<sub>6</sub>; streamer pulses; sulfurhexafluoride; water vapor; corona discharges; electron avalanches; gas chromatograph; *21379*.

mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; moisture measurement; three volume calibration valve; three volume calibrator; water-vapor measurement; mass spectrometer; *SP400-72*; 1982 April. 8-14.

mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; moisture measurement; three volume calibration valve; three volume calibrator; water-vapor measurement; mass spectrometer; mass spectrometer calibration; *SP400-72*; 1982 April. 8-14.

mass spectrometer measurement; moisture; moisture generators; moisture sensors; quality control; reliability of semiconductor devices; semiconductor devices; analysis of moisture content; hermetically packaged semiconductor devices; *SP400-72*.

mass spectrometer sensitivity factor; moisture analysis; moisture measurement; three volume calibration valve; three volume calibrator; water-vapor measurement; mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; *SP400-72*; 1982 April. 8-14.

mass spectrometry; Method 1018; moisture sensors; surface conductivity sensors; aluminum oxide sensors; Cerdip; Cerpak; leak detection; *SP400-72*; 1982 April. 90-97.

mass spectrometry; Method 1018; quantitative analysis; standards; water vapor; certification; *SP400-72*; 1982 April. 32-38.

mass spectrometry; method 1018.2; quantitative analysis; water vapor; calibration; certification; *SP400-72*; 1982 April. 39-48.

mass spectrometry; moisture evolution analysis; water sorption phenomenon; Cerdips; desorption; *SP400-72*; 1982 April. 213-219.

mass spectrometry; moisture sensors; packaging; reliability; standard packages; humidity; *SP400-72*; 1982 April. 19-31.

mass spectrometry; negative molecular ions; Penning ionization source; *20907*.

mass spectrometry; neutron activation; plasma; zinc; dietary enrichment; isotopes; *21374*.

mass spectrometry; on-going monitoring activity; package-sealing environment; aluminum oxide; Cerdip packages; IC assembly; in-situ moisture sensors; LSI circuits; *SP400-72*; 1982 April. 113-116.

mass spectrometry; Penning ion source; atomic negative ions; doubly charged ions; *21370*.

mass spectrometry; photoelectron spectroscopy; photoionization; Xe; clusters; coincidence; *21153*.

mass spectrometry; silica gel; silver; silver iodide; absolute ratios;



atomic weight; Faraday constant; isotopic abundance; *J. Res.* 87(1): 9-19; 1982 January-February.

mass spectrometry; slag vaporization; transpiration; Knudsen effusion; 21282.

mass spectrometry; stable isotope dilution analysis; statistical analysis; total cholesterol analysis; cholesterol analysis; definitive method; isotope dilution/mass spectrometry; 20796.

mass spectroscopy; moisture measurement; gas analysis; gases in hermetic packages; hermetic IC packages; internal water vapor; SP400-72; 1982 April. 15-18.

master planning; material and logistics functions; personnel/component/support shop functions; powerplant/component/support shop functions; aircraft maintenance functions; maintenance information systems functions; management and financial functions; SP640; 1982 October. 27-44.

metabolite of pathogenic fungi; single crystal x-ray diffraction; xanthomycin; absolute configuration; crystal structure; dimer; fungal pigment; 21313.

material and logistics functions; personnel/component/support shop functions; powerplant/component/support shop functions; aircraft maintenance functions; maintenance information systems functions; management and financial functions; master planning; SP640; 1982 October. 27-44.

material and material processing; mechanical and structural failure; operational environment; preventive maintenance; wear; corrosion; failure prevention; human performance; SP640; 1982 October. 2-16.

material parameters; nondestructive evaluation; optics; penetrants; radiography; and ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; magnetics; NBSIR 82-2449.

materials; nonflaming combustion; test method; toxicity; combustion products; flaming combustion; inhalation; NBSIR 82-2532.

materials data; standard reference data; technical activities 1981; thermochemical and thermophysical data; data compilation; energy and environmental data; evaluated data; NBSIR 81-2442.

materials handling; robotics; robots; automation; computer aided manufacturing; glossary; NBSIR 81-2340.

materials logistics; business driver; key volume indicator; SP500-95; 1982 October. 127-133.

materials problems; MHD; fuel cells; gas turbines; high temperature needs; 21260.

materials properties; mechanical properties; physical properties; refractories; alloys; coal conversion; coal gasification; corrosion; erosion; SP642.

materials science; synchrotron radiation; topography; x ray; image formation; kinetic study; 21257.

materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; NBS-GCR-80-204.

materials testing; oxidation; petroleum products; review; additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; NBSIR 82-2490.

mathematical model; pullout test; stress contours; concrete; crack propagation; failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; large scale models; NBSIR 82-2484.

mathematical modeling; measurement; network performance; performance evaluation; computer network; local networking; SP500-95; 1982 October. 389-396.

mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; 21177.

mathematical modeling; numerical methods; unsteady flow; vortex shedding; computer simulation; external aerodynamics; fluid dynamics; 21044.

mathematical modeling; performance/modeling data acquisition; software monitor; application of basic queueing theory; IBM's RMF; job class; SP500-95; 1982 October. 279-296.

mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; 21175.

mathematical modeling; pulse circuits; computer simulation; SP628; 1982 June. 133-149.

mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; TN1150.

mathematical models; room fires; smoke movement; tenability limits; combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; NBSIR 82-2578.

mathematical models; walls; aircraft compartments; aircraft fires; ceilings; compartment fires; computer programs; fire growth; fire models; heat flux; NBS-GCR-82-404.

mathematical models; wind effects; aircraft compartments; aircraft fires; flow rates; NBSIR 82-2537.

mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; 20909.

mathematical programming; rehabilitation; renovation; applied economics; building codes; health and safety; housing; NBSIR 81-2416.

Mathieu's equation; single-pan balance; analytical balance; balance dynamics; balance sensitivity; balance suspension; knife-edge bearings; *J. Res.* 87(1): 23-45; 1982 January-February.

matrix inversion; physical property; elastic constants; error propagation; 20818.

matrix isolation; methyl-d<sub>2</sub> nitrite; methyl nitrite; nitromethane; photolysis; force constants; gas phase; infrared spectrum; 21302.

matrix isolation; methyl nitrite; photodecomposition; CH<sub>3</sub>O; formaldehyde; HNO; hydrogen bonding; infrared spectrum; 21301.

matrix isolation; phenyl; photodecomposition; 1-fluorocyclohexadienyl; benzene; F-atom reactions; infrared spectrum; 20917.

mattresses; nursing homes; room fires; smoldering; fabric flammability; fire models; fire tests; home fires; hospitals; NBSIR 81-2440.

mattresses; smoke control; smoke exhaust; smoke movement; ventilation systems; ceiling systems; hazard analysis; hospitals; interstitial space; NBSIR 81-2444.

mattress flammability; room fire tests; smoke density chamber; smoke measurement; furnishings; furniture; 21095.

maximum strength; mechanical properties; yield strength; Young's modulus; compressive strength; concrete mortar; elongation; low temperature; NBSIR 82-1658.

MEAN approximation; polar molecules; electron-molecule collisions; 20952.

mean occupation time; polymer adsorption; probability of first return; restricted random walk; absorbing points; lattice random walk; 20826.

mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; NBSIR 81-2393.

means of egress; emergency egress; fire protection; fire safety; human behavior in fires; human factors; Life Safety Code; NBSIR 82-2480.

measurement; melting; metals; process control; pulse-echo technique; signal processing; solidification; ultrasonics; interface; 21362.

measurement; metrology; pressure; pressure scale; standards; calibration; 20988.

measurement; national standards; quality assurance; standard reference material; traceability; calibration; ionizing radiation; SP609; 1982 February. 45-58.

measurement; net space charge; electrostatic potential; high efficiency air particulate (HEPA) filters; ion counters; ion density; NBSIR 82-2517.

measurement; network performance; performance evaluation; computer network; local networking; mathematical modeling; SP500-95; 1982 October. 389-396.

measurement; niobium; superconductor; tin; titanium; copper; critical current; electrical property; magnetic field; 21218.

measurement; office-building; radiant; solar; space-heating; air-cooling; air leakage; energy; heat-recovery; insulation; 20961.

measurement; protective coatings; test apparatus; test method; adhesion; NBSIR 82-2535.

measurement; quality assurance; radon; standards; calibration; 20834.

measurement; rating; solar; standards; testing; energy; heat transfer; hot water; 21264.

measurement; solar collector; standards; thermal performance; uncertainty; collector rating; incident angle modifier; 21387.

measurement; third generation ATE; third generation core system; ATE systems; calibration; computer; hardware; SP640; 1982 October. 222.



measurement; x-ray emission lines; x-ray photoelectron spectra; crystal spectroscopy; electrons; excitation; *21330*.

measurement assurance; measurement assurance programs; reference standards; standard capacitors; standard qualification; transfer standards; calibration; *TN1162*.

measurement assurance; measurement services; standards; traceability; calibration; *SP250, 1982 Edition*.

measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; *SP629*.

measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; IC photomask; linear calibration curve; line-spacing; linewidth; *TN1164*.

measurement assurance; radiation therapy; survey; teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; *SP609; 1982 February. 89-97*.

measurement assurance; reference standards; standard capacitors; standard qualification; calibration; *TN1161*.

measurement assurance; statistical control; statistical tests; computer software; FORTRAN; gage blocks; *TN1168*.

Measurement Assurance Programs; measurement quality control; metrology management; special tests; calibration services; documentation; *20925*.

measurement assurance programs; reference standards; standard capacitors; standard qualification; transfer standards; calibration; measurement assurance; *TN1162*.

measurement/evaluated data needs; NBS research capabilities; biomass conversion R&D; bioprocess engineering; biotechnology; chemical industry trends/strategies; commodity organic chemicals; *NBSIR 82-2549*.

measurement methods; measurement systems; standard reference materials (SRM's); industrial atmosphere; lead; *SP619; 1982 March. 29-33*.

measurement methods; performance criteria; project summaries; technical bases; building research; building technology; codes; criteria; *SP446-6*.

measurement methods; semiconductor materials characterization; semiconductors; thermally stimulated measurements; thermometry; deep level measurements; *21144*.

measurement of lamp output; plastic plate; quinoline dye; solar energy; fading; *20798*.

measurement quality control; metrology management; special tests; calibration services; documentation; Measurement Assurance Programs; *20925*.

measurements; attenuation; bandwidth; fiber optic joints; fiber optics; fiber optics-single mode; index profile; *SP641*.

measurements; measurement support system; quality assurance; standards; traceability; calibrations; instruments; ionizing radiation; *SP609; 1982 February. 3-10*.

measurements; metrology; reference materials; semiconductors; silicon; standard reference materials; *20829*.

measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; units; data reporting; detection limit; environmental; lower limit of detection (LLD); *20888*.

measurements; national standards; quality assurance; secondary standard laboratory; traceability; calibrations; ionizing radiation; *SP609*.

measurements; optical fiber; attenuation; backscatter; bandwidth; index profile; *SP637, Volume 1*.

measurements; radiation; radon; radon progeny; standards; states; thoron; calibration; *NBS-GCR-82-394*.

measurements; radioactivity; radiopharmaceutical; standards; traceability; assurance; *SP609; 1982 February. 99-110*.

measurements; radioactivity; standards; system; calibration; intercomparisons; *SP609; 1982 February. 31-37*.

measurements; solar; temperature; fluid flow; instrumentation; irradiance; *21349*.

measurements; standards; traceability; x ray; calibration; instruments; *SP609; 1982 February. 59-64*.

measurement services; standards; traceability; calibration; measurement assurance; *SP250, 1982 Edition*.

measurement standards; radiation dosimetry; standards; calorimeter; cavity ionization chamber; extrapolation chamber; free-air chamber; ionizing radiation; *SP609; 1982 February. 29-30*.

measurement support system; quality assurance; standards; traceability; calibrations; instruments; ionizing radiation; measurements; *SP609; 1982 February. 3-10*.

measurement systems; standard reference materials (SRM's); industrial atmosphere; lead; measurement methods; *SP619; 1982 March. 29-33*.

measurement uncertainties; photon probabilities per decay; relative photon-emission probabilities; compilation; efficiency data; half lives; *SP626*.

measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; *SP400-74*.

measures; metric; program complexity; software testing; structured testing; *SP500-99*.

measures; scales; specifications; taximeters; tolerances; user requirements; volume-measuring devices; weights; length-measuring devices; liquid-measuring devices; *H44*.

mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; cost-effective; data processing; infrared spectrophotometry; integrated reporting system; maintenance management; *SP640; 1982 October. 61-71*.

mechanical and structural failure; operational environment; preventive maintenance; wear; corrosion; failure prevention; human performance; material and material processing; *SP640; 1982 October. 2-16*.

mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve; database; data collection; failure data; inservice data; inservice inspection; *21176*.

mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; *21177*.

mechanical equivalence; mixtures; molecular potential; quantum parameter; corresponding states; critical point universality; liquefaction of helium; *20899*.

mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; weld evaluation; *21242*.

mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; welding evaluation; *21235*.

mechanical properties; physical properties; refractories; alloys; coal conversion; coal gasification; corrosion; erosion; materials properties; *SP642*.

mechanical properties; thermal properties; thermodynamic properties; thermophysical properties; basalt; chemical characterization; data compilation; dielectric properties; electrical properties; *NBSIR 82-2587*.

mechanical properties; yield strength; Young's modulus; compressive strength; concrete mortar; elongation; low temperature; maximum strength; *NBSIR 82-1658*.

mechanical property; titanium alloy; alloy; aluminum alloy; elastic constants; flywheel; iron alloy; mass density; *NSRDS-NBS61, Part V*.

mechanical testing; microstructure; rail vehicles; SEM fractography; cast steels; fatigue crack growth rates; fracture analysis; *SP621; 1982 October. 33-45*.

mechanical testing; multiaxial tests; stress-corrosion; computer controlled mechanical test; crack growth; creep-fatigue; *21111*.

mechanical testing; nondestructive testing; pultrusions; standards; composite materials; damage; fatigue; guys; *21195*.

mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; *21326*.

mechanism; oxidation; reversible; salts; croconates; dicyanomethylene; electrochemical; electron-transfer; *21103*.

mechanism;  $\pi$ -acceptors; semiconduction; conductivity; croconates; crystallographic; electrical; electrochemical; *J. Res. 87(3): 257-260; 1982 May-June*.

median; statistical methods; concave; convex; inequality; majorization; *J. Res. 87(1): 71-74; 1982 January-February*.



medical physics; nonionizing radiation; nuclear medicine; radiation therapy; data handbook; diagnostic radiology; general physics; *H138*.

melt; polystyrene; atactic; crystal; crystallinity; density; enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; *JPCRD 11(2)*: 313-325; 1982.

melt crystallization; polyethylene; polyethylene fold planes; polymer; polymer crystallization; SANS; semicrystalline polymer; adjacent reentry; fold plane roughening; *21160*.

melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon; crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; *20900*.

melting; metals; process control; pulse-echo technique; signal processing; solidification; ultrasonics; interface; measurement; *21362*.

melting; normal spectral emittance; pulse heating; radiance temperature; tungsten; *21227*.

melting line; normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; *Monogr. 169*.

melting line; orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; *Monogr. 170*.

melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; *TN1051*.

melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; aluminum point; cadmium point; check thermometers; freezing point; *SP260-77*.

melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon; crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; melt index; *20900*.

melts; oxidation; reduction; terbium; glass; luminescence; *21315*.

membrane; purification; separation; chemical engineering; facilitated transport; liquid membrane; *21241*.

membrane filter method; statistical considerations; airborne asbestos; error distributions; Gaussian assumptions; *SP619*; 1982 March. 145-153.

membrane properties; roofing membranes; single-ply roofing; tensile strength; test methods; elongation; exposure conditions; *20841*.

membranes; olfaction; protein separation; chemical analysis; electrochemistry; *NBS-GCR-82-378*.

memory management; optimal memory allocation; stochastic control theory; *SP500-95*; 1982 October. 155-172.

mental disorders; board and care homes; developmentally disabled; elderly persons; evacuation; fire emergency planning; fire protection; group homes; *NBS-GCR-82-408*.

mercury; solubility of alloys in mercury; dental amalgam; *20850*.

mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; aluminum point; cadmium point; check thermometers; freezing point; melting point; *SP260-77*.

meson exchange current; nucleus; photon; pion; electron; Fermi gas model; Feynman diagrams; *21345*.

message delay; network throughput; survivability; alternate routing; communications networks; distributed control; *20994*.

metal coating; polymer coating; rust prevention; vehicular rust; battery-acid corrosion; *SP640*; 1982 October. 275-289.

metal distress; metal parts; NDE; nickel base alloys; testing; defect detection; eddy current; failure prevention; ferro-magnetic alloys; inspection; *SP640*; 1982 October. 454.

metal hydride; neutron scattering; niobium hydride; tritide; vibration spectra; defect; isotope; *20948*.

metallic glasses; nickel-phosphorus; steel; wear; wear testing; chromium; coatings; electrodeposition; *21232*.

metallic glasses; palladium-copper-silicon alloys; rapid solidification; amorphous alloys; coupled growth; eutectic solidification; *21190*.

metallic multilayers; reflectivity; resolving power; synchrotron radiation; 1 keV photon energy region; beryl; KAP; *21088*.

metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground; alloys; corrosion; *NBSIR 82-2509*.

metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; *NBSIR 81-2413*.

metal parts; NDE; nickel base alloys; testing; defect detection; eddy current; failure prevention; ferro-magnetic alloys; inspection; metal distress; *SP640*; 1982 October. 454.

metals; nuclear waste; underground; alloys; containers; corrosion; corrosion data; geothermal brines; *NBSIR 81-2409*.

metals; plastic-bonded; soils; telephone cables; underground; alloys; corrosion; metallurgically-bonded; *NBSIR 82-2509*.

metals; polymers; resistance; resistivity; review; alloys; conductivity; electrical property; *TN1053*.

metals; process control; pulse-echo technique; signal processing; solidification; ultrasonics; interface; measurement; melting; *21362*.

metal vapors; radiation trapping; resonance radiation; fluorescence; ionization; laser ionization; *21289*.

metastable states; optical pumping; atomic beam; hydrogen; *21102*.

metastable transition; photoelectron photoion coincidence; propylene; proton affinity; alkyl halide; breakdown curve; *21097*.

meteorology; structural engineering; wind; climatology; extreme winds; fluid mechanics; *21212*.

metering; rate structures; water conservation; consumer education; energy conservation; feedback; incentives; *NBSIR 80-2119*.

metering accuracy CCVTs; 500 kV; 500 kV substation measurements; CCVTs; EHV revenue metering; energy metering; field calibration; *TN1155*.

methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; *20825*.

methane; buoyancy; diffusion flames; flame research; heat flux; *NBS-GCR-82-367*.

methane; densimeter; density; liquefied natural gas; *TN1055*.

methane; methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; *JPCRD 11(1)*: 83-99; 1982.

methanol; methanol-d; methanol-d<sub>2</sub>; deuterium; electron stimulated desorption; ESD; ion kinetic energy distribution; *21133*.

methanol; methoxy; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; hydrogen; *21296*.

methanol; silicone coating; UV light; hermeticity; hybrid; leak test; *SP400-72*; 1982 April. 271-274.

methanol-d; methanol-d<sub>2</sub>; deuterium; electron stimulated desorption; ESD; ion kinetic energy distribution; methanol; *21133*.

methanol-d<sub>2</sub>; deuterium; electron stimulated desorption; ESD; ion kinetic energy distribution; methanol; methanol-d; *21133*.

methanol-water mixtures; solvent contraction; solvent-water mixtures; water determination; water extraction; Karl Fischer titration; *21277*.

method of sale of commodities; open dating; packaging and labeling; registration of servicepersons; unit pricing; Weighmaster Law; basic weights and measures law; *H130*, 1983 Edition.

methodologies; strategies; techniques; concepts; Information Resource Management; Information Systems Management; management-tool; *SP500-95*; 1982 October. 5-9.

methodology manual; standardized measurement protocol; airborne asbestos fibers; electron microscopic analysis; EPA-NBS agreement; *SP619*; 1982 March. 1-4.

methods, analytic; silicon; techniques, spectroscopic; FT-IR; infrared; interferograms, tertiary; *20828*.

methods of measurement; nutrients; SRM's; stability; vitamins; food matrices; *SP635*.

Method 1018; moisture sensors; surface conductivity sensors; aluminum oxide sensors; Cerdip; Cerpak; leak detection; mass spectrometry; *SP400-72*; 1982 April. 90-97.

Method 1018; quantitative analysis; standards; water vapor; certification; mass spectrometry; *SP400-72*; 1982 April. 32-38.

method 1018.2; quantitative analysis; water vapor; calibration; certification; mass spectrometry; *SP400-72*; 1982 April. 39-48.

methoxy; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; hydrogen; methanol; *21296*.



methylation; oil shale retorting; organometallics; process waters; shale oil; speciation; arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; 21125.

methyl- $d_3$  nitrite; methyl nitrite; nitromethane; photolysis; force constants; gas phase; infrared spectrum; matrix isolation; 21302.

methylene; radicals; vinylidene; energetics; excited states; kinetics; 20783.

methyl group; neutron scattering; nitromethane; reorientation; tunnel states; deuterated; 20895.

methyl iodide ( $\text{CH}_3\text{I}$ ); methyl radical ( $\text{CH}_3$ ); photodissociation; photofragmentation; 21113.

methyl iodide ( $\text{CH}_3\text{I}$ ); methyl radical ( $\text{CH}_3$ ); photodissociation; photofragmentation; 21114.

methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; 20955.

methyl nitrite; nitromethane; photolysis; force constants; gas phase; infrared spectrum; matrix isolation; methyl- $d_3$  nitrite; 21302.

methyl nitrite; photodecomposition;  $\text{CH}_3\text{O}$ ; formaldehyde;  $\text{HNO}$ ; hydrogen bonding; infrared spectrum; matrix isolation; 21301.

methyl radical; acetylenes; azomethanes; critically evaluated data; diazine dimethyls; enthalpy of formation; entropy; ethane; ethylene; Gibbs energy of formation; ideal gas thermodynamic properties; internal rotation; methane; *JPCRD 11(1)*: 83-99; 1982.

methyl radical ( $\text{CH}_3$ ); photodissociation; photofragmentation; methyl iodide ( $\text{CH}_3\text{I}$ ); 21114.

methyl radical ( $\text{CH}_3$ ); photodissociation; photofragmentation; methyl iodide ( $\text{CH}_3\text{I}$ ); 21113.

methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; 20999.

methyl viologen; nonaqueous; thin layer spectroelectrochemistry; vacuum; 20872.

metric; program complexity; software testing; structured testing; measures; *SP500-99*.

metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance; *SP629*.

metric symmetry; reduced cell; crystallography; data analysis; determinative ratios; FORTRAN program; 21269.

metric system; status and future; economic benefits; industry; International System of Units (SI); 21120.

metrology; pressure; pressure scale; standards; calibration; measurement; 20988.

metrology; reference materials; semiconductors; silicon; standard reference materials; measurements; 20829.

metrology; spectroscopy; atomic beams; cesium; frequency standards; lasers; 21252.

metrology management; special tests; calibration services; documentation; Measurement Assurance Programs; measurement quality control; 20925.

metrology support; phase angle calibration; signal sampling; stability; waveform synthesis; ac-dc difference; data conversion; dynamic response; linearity; 21027.

$\text{Mg}^+$ ; Na iso-sequence;  $\text{Si}^{+3}$ ;  $\text{Al}^{+2}$ ; crossed beams; cross sections; electron impact; excitation-autoionization; ionization; 21073.

MHD; fuel cells; gas turbines; high temperature needs; materials problems; 21260.

Michelson interferometer; optical path-length correction; phase comparator; real-time control; vibration control; vibration isolation; active vibration control; 21403.

MICR; MICR Read Optically; OCR; optical character recognition; character shapes; data entry; Federal Information Processing Standard; graphic shapes; magnetic ink characters; *FIPS PUB 32-1*.

microanalysis; microscopy; electron microscopy; electron probe microanalysis; ion probe; laser Raman probe; 20897.

microanalysis; normal alkanes; Raman microprobe; Raman spectroscopy; vibrational analysis; hexagonal urea lattice; inclusion compounds; 20996.

microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; 21326.

microchannel plate; multiple-pinhole mask; spectrometer; telescope; x ray; digitizing anode; gamma ray; 21366.

microcircuits; MIL-STD-8833; moisture measurement; moisture standards; analytical laboratories; correlation; *SP400-72*; 1982 April. 126-127.

microcircuits; moisture; moisture sensors; reliability; humidity; hybrids; *SP400-72*; 1982 April. 178-183.

microcircuits; moisture; reliability; water vapor; derivative spectroscopy; diode laser; humidity; infrared; *SP400-72*; 1982 April. 105-109.

microcomputer; administrative system for maintenance; automatic condition monitoring; condition monitoring module; *SP640*; 1982 October. 71-85.

microcomputer; analog signal conditioning; data acquisition system; field data acquisition; field instrumentation; field performance of heat pumps; heat pumps; heat pump test methods; *NBSIR 81-2285*.

microcomputer; rms value; sampling; signal period; algorithm; converter; distortion; *TN1159*.

microcomputers; periodical literature and documentation; software documentation; user's groups; verbal documentation; beginning computer users; documentation; hardware systems documentation; large computer manufacturers; *SP500-94*; 1982 October. 174-179.

microcrystalline; nucleation; recalcence; solidification; undercooling; amorphous; cooling rate; crystalline; dendrites; interfaces; 21090.

microdosimetric parameters; bin-averaged cross sections; dose-averaged energy loss; energy deposition spectra; energy distributed neutron spectra; frequency averaged energy loss; 21029.

microelectronic package; moisture; moisture level; relative humidity; sorption thermodynamics; absorption; adsorption; dew point; hygrometer; kinetics; *SP400-72*; 1982 April. 184-200.

microelectronic packaging; thermal shock; vibration; acoustic emission; hermeticity; hybrid microelectronics; hybrid packages; *SP400-70*.

microelectronics; process control; process validation wafer; silicon on sapphire; test chip; test pattern; test structure; yield; integrated circuits; *NBSIR 82-2514*.

microelectronics; process control; process validation wafer; test pattern; test structure; wafer map; integrated circuits; 20838.

microelectronics; process-related radiation damage; radiation dose; device fabrication; electron-beam metallization; electron devices; ionizing radiation; 21184.

microelectronic test chips; parametric testers; test methods; integrated circuits; 20956.

microelectronic test structure; process control; sheet resistance; test structure; cross-bridge structure; linewidth; *NBSIR 82-2548*.

microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; *NBSIR 81-2413*.

microenvironments; moisture related failures; temperature effects on surface water; accelerated moisture testing; *SP400-72*; 1982 April. 165-174.

microhomogeneity; mineral glasses; standard reference material; chemical analysis; digital periodic integrator; electron probe microanalysis; glass standards; homogeneity testing; *SP260-74*.

micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; *SP400-74*.

microphone cable; mobile transceiver; performance standard; cable assembly; cable connector; control cable; control head; D-subminiature connector; interchangeability; law enforcement; 20904.

microprocessor; network; serial; broadcast; coaxial; communication; contention; data; digital; Ethernet; local; 20839.

microprocessor control; pneumatic control system; velocity algorithm; building controls; digital-to-pneumatic conversion; direct digital control; energy controls; HVAC system; 20995.

microprocessor controlled test set; symptom; test strategy; automated test equipment; fault isolation diagnostics; functional subsystem; line replaceable units; malfunction; *SP640*; 1982 October. 223-234.

microprocessors; personal computers; small computers; software; word processing; *NBSIR 82-2573*.



microscopy; electron microscopy; electron probe microanalysis; ion probe; laser Raman probe; microanalysis; 20897.

microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; *NBS-GCR-80-204*.

microscopy; orthorhombic; surfaces; uranium; hydride; hydrogen; 21021.

microspheres; Mie theory; optical levitation; particle sizing; polarization ratio; radiation pressure; resonances; light scattering; liquid droplets; 21054.

microstructure; rail vehicles; SEM fractography; cast steels; fatigue crack growth rates; fracture analysis; mechanical testing; *SP621*; 1982 October. 33-45.

microstructures; titanium; alloys; anodic polarization; corrosion; fatigue; 21174.

microwave; molecular spectroscopy; rotational spectra; ultraviolet; vibrational spectra; visible; electronic spectra; infrared; 21388.

microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; *NBS-GCR-80-204*.

microwave frequency standard; optical frequency standard; stored ions; atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; 21202.

microwave power level changes; servo; sidelobe atomic peak; atomic clock; atomic resonance frequency error; fixed offset frequency; main atomic peak; *U.S. Patent 4,331,933*.

microwaves; nondestructive evaluation; radiography; tire inspection; ultrasonics; visual-optical; acoustic emission; eddy currents; liquid penetrants; magnetic particles; 20957.

microwave spectra; molecular constants; propionitrile; radio astronomy; rotational spectrum; ethanol; intensities; interstellar molecules; *JPCRD 11(2)*: 251-312; 1982.

microwave spectrum; molecular structure; rotational spectrum; structure; borane monoammoniate; electric dipole moment; 21337.

microwave spectrum; ozone-olefin reactions; structure; air pollution; dioxirane; dipole moment; 21340.

microwave transitions; rotational transitions; absorption coefficients; carbonyl sulphide; intensities; *JPCRD 11(1)*: 101-117; 1982.

MICR Read Optically; OCR; optical character recognition; character shapes; data entry; Federal Information Processing Standard; graphic shapes; magnetic ink characters; MICR; *FIPS PUB 32-1*.

midgap absorption; nonhydrogenic states; polaron; polyacetylene; soliton; doping; impurity states; 21104.

Mie theory; optical levitation; particle sizing; polarization ratio; radiation pressure; resonances; light scattering; liquid droplets; microspheres; 21054.

migration; octylins; poly(vinyl chloride); diffusion; extraction; food packaging; heat stabilizers; 21325.

migration; octylins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; *NBSIR 81-2314*.

migration; oligomers; polyethylene; polypropylene; radiotracer; antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; *NBSIR 82-2472*.

MIL-STD-8833; moisture measurement; moisture standards; analytical laboratories; correlation; microcircuits; *SP400-72*; 1982 April. 126-127.

mineral glasses; standard reference material; chemical analysis; digital periodic integrator; electron probe microanalysis; glass standards; homogeneity testing; microhomogeneity; *SP260-74*.

minimax; peak area; smoothing; spectroscopy; splines; statistical methods; linear models; *J. Res. 87(1)*: 53-65; 1982 January-February.

minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; units; data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; 20888.

Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; *NBSIR 82-2562*.

minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; *SP640*; 1982 October. 257-274.

MIR (multiple internal reflectance); on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; cost-effective; data processing; infrared spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; *SP640*; 1982 October. 61-71.

misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; *SP640*; 1982 October. 257-274.

Mississippi; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-353*.

mixed sampling plan; order statistics; statistical methods; acceptance probability; compliance sampling; dual acceptance criteria; *J. Res. 87(6)*: 485-511; 1982 November-December.

mixed-valence; photoionization; resonance; ytterbium; Auger; core-holes; 21105.

mixing angles; neutrino oscillations; potentials; scaling; Fermion masses; internal spaces; 21168.

mixing ratios; nuclear magnetic moment; nuclear orientation; nuclear quadrupole moment;  $\gamma$ -ray anisotropy thermometry;  $\gamma$ -ray transitions in  $^{166}\text{Er}$ ,  $^{166}\text{Ho}$ ; 20978.

mixtures; molecular potential; quantum parameter; corresponding states; critical point universality; liquefaction of helium; mechanical equivalence; 20899.

mixtures; second virial coefficients; vapor-liquid equilibrium; vapor pressure; volume change of mixing; equations of state; heat of mixing; liquid density; *JPCRD 11(3)*: 941-951; 1982.

M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; throughput; transition matrix; carrier sense multiple access; channel access; load dependent; local area networks; *SP500-95*; 1982 October. 365-373.

mobile digital terminals; voice message traffic; digital communications equipment; digital techniques; equipment standards; law enforcement; *NBS-GCR-81-356*.

mobile home; overall system efficiency; residential furnaces; room temperature; thermal response factors; thermostat control; burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; 20903.

mobile homes; soil anchors; soil mechanics; stiffness; wind forces; anchors; cyclic loading; field testing; flood forces; foundations; load capacity; *BSS142*.

mobile transceiver; performance standard; cable assembly; cable connector; control cable; control head; D-subminiature connector; interchangeability; law enforcement; microphone cable; 20904.

Mode I brittle crack; activation energy for double kink formation; boundary conditions for atomic simulations; brittle crack growth rate; double kink nucleation; edge dislocation pileup; equilibrium jog array; 21193.

modeling; models; software monitors; analytic modeling; capacity planning; computer performance; *SP500-95*; 1982 October. 81-84.

modeling; monitoring; research; steam; thermal response; valve; air conditioning; building systems; computer; control; heat exchanger; 21048.

modeling; MVS; performance measurement data; software tuning; data tuning; *SP500-95*; 1982 October. 313-320.

modeling; NBS; solar; solar domestic hot water system; stratification; test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; *BSS140*.

modeling; office building; thermal response; ventilation; air conditioning; air distribution; building systems; computer; control; 21047.

modeling; packet switch; performance evaluation; simulation; trunk; WIN; analytical; capacity planning; central server; disk; main memory contention; *SP500-95*; 1982 October. 97-106.

modeling; pedestrian movement; regulatory process; simulation of human behavior; building codes; building fires; computer-aided design; computer simulation; emergency egress; fire research; human performance; 20911.

modeling; performance evaluation; simulation; UNIVAC systems; *SP500-95*; 1982 October. 231-257.

model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance;



metrication; *SP629*.  
 modelling; queueing network models; efficient evaluation algorithms; *SP500-95*; 1982 October. 437.  
 model manual; monitoring; Resource Conservation and Recovery Act; State measurement needs; test protocols; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-355*.  
 model microfield; plasma; Stark; strong collisions; line broadening; 20846.  
 mode-locked; picosecond; pulse emission; streak-camera; tunable; dye laser; 21348.  
 models; osmotic coefficient; polyvalent electrolytes; thermodynamics properties; activity coefficient; correlation; critical evaluation; electrolyte theories; 20935.  
 models; software monitors; analytic modeling; capacity planning; computer performance; modeling; *SP500-95*; 1982 October. 81-84.  
 models of concept relations; similarity; term relations; automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; 21250.  
 mode-matching analysis; spatial filter; target designators; computer simulation; laser beam profile; *TN1057*.  
 modular capacitive divider; portable system; truck-mounted; CCVT; compact; field calibration; high accuracy; 21287.  
 modulated cw measurement system; PIN transfer standards; pulse energy; pulse peak power; 1.064  $\mu\text{m}$  laser pulse measurements; APD transfer standards; beamsplitter attenuator; impulse response measurements; low-level laser measurements; *TN1058*.  
 modulating control gas-fueled; two-stage thermostat; annual efficiency; household heaters and furnace test procedures; hydraulic thermostat control; *NBSIR 82-2497*.  
 modulation; noise; acousto-optic; bandshape; bandwidth; broadening; laser; 21375.  
 moisture; moisture generators; moisture sensors; quality control; reliability of semiconductor devices; semiconductor devices; analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; *SP400-72*.  
 moisture; moisture level; relative humidity; sorption thermodynamics; absorption; adsorption; dew point; hygrometer; kinetics; microelectronic package; *SP400-72*; 1982 April. 184-200.  
 moisture; moisture sensors; reliability; humidity; hybrids; microcircuits; *SP400-72*; 1982 April. 178-183.  
 moisture; monolayer buildup; egress; ingress; integrated circuit package; *SP400-72*; 1982 April. 258-270.  
 moisture; nichrome resistors; semiconductor devices; dew point; failure; hybrid microcircuit; *SP400-72*; 1982 April. 175-177.  
 moisture; nuclear safeguards; plutonium dioxide; water determination; automatic titration; Karl Fischer reagent titration; *NBSIR 82-2496*.  
 moisture; operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; *SP640*; 1982 October. 257-274.  
 moisture; packaging; water vapor; contamination; dew point; hermetic packages; *SP400-72*; 1982 April. 76-78.  
 moisture; reliability; water vapor; derivative spectroscopy; diode laser; humidity; infrared; microcircuits; *SP400-72*; 1982 April. 105-109.  
 moisture; roofing; thermal conductance; thermal conductivity; thermal resistance; built-up roofing; insulation; 21354.  
 moisture analysis; moisture measurement; three volume calibration valve; three volume calibrator; water-vapor measurement; mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; *SP400-72*; 1982 April. 8-14.  
 moisture effect; phenolic resin; specific heat; thermosetting polymers; varnishes; adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; 21032.  
 moisture effects; composites; elastic properties; flux deviation; 21196.  
 moisture evolution; package reliability; sealing glass; Cerdip; integrated circuit packaging; internal water vapor; *SP400-72*; 1982 April. 220-233.  
 moisture evolution analysis; water sorption phenomenon; Cerdips; desorption; mass spectrometry; *SP400-72*; 1982 April. 213-219.  
 moisture generators; moisture sensors; quality control; reliability of semiconductor devices; semiconductor devices; analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; *SP400-72*.  
 moisture intrusion in avionic equipment; avionic component design; avionic corrosion damage; corrosion damage; equipment design failures; marine environmental factors; *SP640*; 1982 October. 379-399.  
 moisture level; relative humidity; sorption thermodynamics; absorption; adsorption; dew point; hygrometer; kinetics; microelectronic package; moisture; *SP400-72*; 1982 April. 184-200.  
 moisture measurement; gas analysis; gases in hermetic packages; hermetic IC packages; internal water vapor; mass spectroscopy; *SP400-72*; 1982 April. 15-18.  
 moisture measurement; moisture standards; analytical laboratories; correlation; microcircuits; MIL-STD-8833; *SP400-72*; 1982 April. 126-127.  
 moisture measurement; oxide moisture sensors; hybrids; *SP400-72*; 1982 April. 110-112.  
 moisture measurement; oxygen; software; sorption; water; algorithms; calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; *SP400-72*; 1982 April. 3-7.  
 moisture measurement; surface conductivity moisture monitor; gas analysis; hermetic IC packages; in-situ moisture monitor; internal water vapor; *SP400-72*; 1982 April. 64-75.  
 moisture measurement; three volume calibration valve; three volume calibrator; water-vapor measurement; mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; *SP400-72*; 1982 April. 8-14.  
 moisture permeation; polymeric materials; solubility; diffusion; hydrophobic; *SP400-72*; 1982 April. 239-245.  
 moisture related failures; temperature effects on surface water; accelerated moisture testing; microenvironments; *SP400-72*; 1982 April. 165-174.  
 moisture reliability; plastic encapsulation; surface conductivity; integrated circuits; *SP400-72*; 1982 April. 247-257.  
 moisture sensors; packaging; reliability; standard packages; humidity; mass spectrometry; *SP400-72*; 1982 April. 19-31.  
 moisture sensors; pn junction temperature sensor; surface conductivity sensor; time response of moisture sensors; aluminum oxide moisture sensor; *SP400-72*; 1982 April. 79-89.  
 moisture sensors; quality control; reliability of semiconductor devices; semiconductor devices; analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; moisture generators; *SP400-72*.  
 moisture sensors; reliability; humidity; hybrids; microcircuits; moisture; *SP400-72*; 1982 April. 178-183.  
 moisture sensors; surface conductivity sensors; aluminum oxide sensors; Cerdip; Cerpak; leak detection; mass spectrometry; Method 1018; *SP400-72*; 1982 April. 90-97.  
 moisture sources; adsorption; corrosion; dew point; failure modes; hybrid manufacturing; *SP400-72*; 1982 April. 117-125.  
 moisture standards; analytical laboratories; correlation; microcircuits; MIL-STD-8833; moisture measurement; *SP400-72*; 1982 April. 126-127.  
 molecular collisions; stopping cross sections; adiabatic nuclei approximation; 21074.  
 molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; ferroelectric; 21392.  
 molecular constants; propionitrile; radio astronomy; rotational spectrum; ethanol; intensities; interstellar molecules; microwave spectra; *JPCRD 11(2)*: 251-312; 1982.  
 molecular constants; spectral shape; collision-induced dipoles; collision-induced spectra; dielectric virial; intermolecular interactions; 21167.  
 molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; 20836.  
 molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation; activation analysis; crystal structure; diffraction; isotopes; *TN1160*.  
 molecular dynamics; non-ergodic; relaxation; velocity autocorrelation; distribution functions; hard rods; 21283.  
 molecular dynamics; rubidium; anharmonic effects; Debye-Waller factor; lattice dynamics; lithium; 21096.  
 molecular energy splitting; two-Coulomb-center problem; highly excited states of  $E(Z_1eZ_2)$  system; 21376.



molecular fluorescence; surface geometry; surface spectroscopy, field enhancement; 21031.

molecular polarizabilities; vibrational polarizabilities; atomic polarization; dipole polarizabilities; infrared intensities; *JPCRD* 11(1): 119-133; 1982.

molecular potential; quantum parameter; corresponding states; critical point universality; liquefaction of helium; mechanical equivalence; mixtures; 20899.

molecular relaxation; vibration; energy transfer; hydrogen halide; *JPCRD* 11(3): 953-996; 1982.

molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; 21185.

molecular spectroscopy; multiphoton chemistry; carbene; hydroxyl; laser chemistry; laser excited fluorescence; 21391.

molecular spectroscopy; rotational spectra; ultraviolet; vibrational spectra; visible; electronic spectra; infrared; microwave; 21388.

molecular spectroscopy; transition moments; tunable lasers; anharmonicity; combination band; high-resolution; 20924.

molecular structure; potential functions; spectroscopy; absorption; high temperature; hydrogen isocyanide; infrared; 20782.

molecular structure; rotational spectrum; structure; borane monoammoniate; electric dipole moment; microwave spectrum; 21337.

molecular structure; spectroscopy; vibrational spectra; bond distances; carbon diselenide; infrared; 20801.

molecular structure; USP reference standard; x-ray diffraction; analgesic; anticonvulsant; azepine ring; carbamazepine; crystal structure; 21298.

molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; 20955.

molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; 21185.

molecules; photoionization; atoms; cross section; electron-ion pairs; electron shells; 21056.

molten salts; self-diffusion coefficients; diffusion; diffusion coefficients; diffusion techniques; fused salts; *JPCRD* 11(3): 505-693; 1982.

molybdenum; niobium; spectra; strontium; vacuum ultraviolet; yttrium; zirconium; 21179.

molybdenum disulphide imbedment; carbide precipitation; decarburization zones; implantment by mechanical inclusion; macro-molecular clustering; *SP640*; 1982 October. 187-193.

momentum acceptance; nucleon; pair correlation function; resolution; solid angle; spectrometer; 21402.

monitor; network; performance; remote; response time; series/1; sidestreaming; simulated commands; 327X emulator; accurate data; end user; host independent; *SP500-95*; 1982 October. 401-407.

monitoring; overhaul; productivity; vibration; balancing; diagnostics; faults; jet engines; *SP640*; 1982 October. 115-129.

monitoring; research; steam; thermal response; valve; air conditioning; building systems; computer; control; heat exchanger; modeling; 21048.

monitoring; Resource Conservation and Recovery Act; State measurement needs; test protocols; analytical procedures; hazardous waste management; lab procedures; model manual; *NBS-GCR-81-355*.

monochromatic resonance; multiphoton; perturbation theory; radiation; sodium atom; time development; transient effects; ionisation; linear polarization; 21075.

monochromator; synchrotron radiation; toroidal grating monochromator; vacuum ultraviolet monochromator; far ultraviolet radiation; grating; 21079.

monochromator efficiency; synchrotron radiation; toroidal grating; ultrahigh vacuum; vacuum ultraviolet; grazing incidence; 21069.

monolayer buildup; egress; ingress; integrated circuit package; moisture; *SP400-72*; 1982 April. 258-270.

monopole; tracking; tuneable; active; antenna; filter; 20892.

Monte Carlo; point-monodirectional beams; superposition; treatment planning; dosimetry; electrons; *NBSIR* 82-2451.

Monte Carlo; polyethylene; polymer; polymer between two plates; rotational isomeric state model; switchboard model; gambler's ruin problem; 21138.

monthly average earth temperature; thermal response factors; building heat transfer; DoE-2 energy analysis computer program; *NBSIR* 81-2420.

morphology; polyethylene; stress-crack resistance; stress-relaxation; ultra high molecular weight; creep; fatigue; *NBSIR* 82-2493.

MOSFET; density of states; Hall effect; inversion layer; Landau level; 20942.

MOSFETs; MOS power transistors; neutron radiation effects; power transistors; radiation effects; semiconductor devices; VDMOS; drain-source resistance; electron devices; gamma radiation effects; 21000.

MOSFETs; neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; *NBSIR* 81-2413.

MOS power transistors; neutron radiation effects; power transistors; radiation effects; semiconductor devices; VDMOS; drain-source resistance; electron devices; gamma radiation effects; MOSFETs; 21000.

Mössbauer effect; alloying; alloy phase diagrams; charge transfer; hybridization; isomer shift; 20820.

MOS transistor; elliptic solvers; finite elements; interactive graphics; *NBSIR* 82-2471.

motion; partially-filled pipe; slope; solid; stream-depth; surge; transport; velocity; water; equation; flow; horizontal; *NBSIR* 81-2450.

motives; psychiatry; psychopathic personality; psychopathology; arson; behavior disorder; fire; firesetters; 21335.

motor carriers; pipelines; rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; *SP621*.

motor oil; petroleum oil; recycled oil; re-refined oil; test procedures; basestock; engine lubricants; lubricating oil; 20990.

motor vehicle equipment; motor vehicles; NHTSA; safety-related defects; safety standards; auto safety hotline; defects; *SP621*; 1982 October. 212-214.

motor vehicles; NHTSA; safety-related defects; safety standards; auto safety hotline; defects; motor vehicle equipment; *SP621*; 1982 October. 212-214.

MRDF; numeric data files; software summary; ANSI Z39.2; bibliographic control; FIPS 30; format structure; machine-readable cataloging; machine-readable data files; MARC; *SP500-94*; 1982 October. 189-196.

multiaxial tests; stress-corrosion; computer controlled mechanical test; crack growth; creep-fatigue; mechanical testing; 21111.

multicharged ions; scattering; autoionization; collisions; dielectronic recombination; 20880.

multicharged ions theoretical; double resonant charge exchange; ion-ion collision processes; 21149.

multiconfiguration; photodissociation; self-consistent field theory; ab initio; electronic structure; 21308.

multicrystal diffraction; real time; synchrotron; topography; x-ray image magnification; 21259.

multidimensional chromatographic analysis; on-line sequential liquid chromatographic analysis; polynuclear aromatic hydrocarbons; shale oil analysis; solvent refined coal; determination of benzo[a]pyrene; 20981.

multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; *NBSIR* 82-2562.

multifunction; parametric tester; reliability; standard; test chip; test structure; custom; integrated circuits; 20835.

multi-housing properties; plumbing fixtures; water consumption; water-saving plumbing; control water flow; flow control devices; *SP624*; 1982 June. 47-51.

multilayer Laplace equation; probe spacing; sheet resistance; spreading resistance; 20984.

multi-level iterations; triangulations; adaptive meshes; eigenvalues; elliptic equations; finite elements; 20823.

multiphoton; nanosecond; photochemistry; picosecond; DNA; 21339.

multiphoton; nonresonant; atomic sodium; high power laser; ionization; 21003.

multiphoton; optogalvanic; two photons; energy transfer; flames; ionization; 21132.



multiphoton; perturbation theory; radiation; sodium atom; time development; transient effects; ionisation; linear polarization; monochromatic resonance; *21075*.

multiphoton chemistry; carbene; hydroxyl; laser chemistry; laser excited fluorescence; molecular spectroscopy; *21391*.

multiphoton dissociation; product state distributions; review infrared multiphoton dissociation;  $\text{CF}_2\text{HCl}$ ;  $\text{CF}_2\text{CFCl}$ ; infrared excitation; *21334*.

multiphoton dissociation; unimolecular dissociation rates;  $\text{CF}_2\text{HCl}$  (chlorodifluoromethane); induction times; infrared laser; intensity dependence in infrared photochemistry; laser chemistry; laser excited fluorescence; *21342*.

multiphoton processes; unimolecular reactions; vibrational relaxation; energy transfer; intramolecular dynamics; laser-excited fluorescence; laser-induced chemistry; *21341*.

multiple injection; smoke candle test; smoke control; stairwell pressurization; top injection; tracer gas test; bottom injection; *21307*.

multiple ionization; vacancies; x-ray emission; electron production; *21261*.

multiple-pinhole mask; spectrometer; telescope; x ray; digitizing anode; gamma ray; microchannel plate; *21366*.

Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; *SP640*; 1982 October. 235-254.

multiterawatt accelerators; particle beam fusion; peak gap voltage; voltage monitor; insulated transmission lines; magnetic insulation; *SP628*; 1982 June. 80-86.

municipal solid waste; recycling; resource recovery; standards; steel; ferrous scrap; iron; *21358*.

municipal solid waste; refuse; refuse-derived-fuel; 25 gram capacity flow calorimeter; enthalpy of combustion; flow calorimetry; *NBSIR 82-2457*.

municipal solid waste; refuse-derived fuel; sample characterization; sample variability; calorific value; flow calorimetry; kilogram-size samples; *NBSIR 82-2491*.

municipal water systems; potable water reduction; water conservation; *SP624*.

MVS; performance measurement data; software tuning; data tuning; modeling; *SP500-95*; 1982 October. 313-320.

MVS SRM; resource-sensitive job scheduling; service levels; SMF exits; workload scheduling; batch; DSNAM ENQUEUE conflict management; *SP500-95*; 1982 October. 297-311.

myth of abundant water; quality degradation; water conservation; depletion of supply; *SP624*; 1982 June. 155-156.

## N

Na iso-sequence;  $\text{Si}^{+3}$ ;  $\text{Al}^{+2}$ ; crossed beams; cross sections; electron impact; excitation-autoionization; ionization;  $\text{Mg}^+$ ; *21073*.

named common blocks; OMNITAB 80; overlay; segmentation; system parameters; transportable computer software; ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; *TN1163*.

nanogram sensitivity; organotin cations; speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; *21272*.

nanosecond; photochemistry; picosecond; DNA; multiphoton; *21339*.

National Bureau of Standards; network protocols; standards; computer networks; Federal Information Processing Standards; International Organization for Standardization; local area networks; *21363*.

National Bureau of Standards; radiation; standards; traceability; calibration; definitions; hierarchy of standards; *SP609*; 1982 February. 11-17.

National Environmental Specimen Bank; specimen banking; storage evaluation and analysis; environment; human health; *21126*.

national product standards; performance standards; international standards; international test methods; *21163*.

national programs; accreditation; ILAC; laboratories; *SP632*; 1982 March. 76-78.

national quality assurance; natural-matrix reference materials;

radioactivity measurements; radiopharmaceuticals; traceability; environmental measurements; international quality assurance; *20883*.

national radiation standards; radiation therapy; calibration; field instruments; *SP609*; 1982 February. 81-88.

national standards; quality assurance; secondary standard laboratory; traceability; calibrations; ionizing radiation; measurements; *SP609*.

national standards; quality assurance; standard reference material; traceability; calibration; ionizing radiation; measurement; *SP609*; 1982 February. 45-58.

natural convection; nonlinear convection; numerical integration; transient fluid motion; transient heat transfer; compressible fluid motion; convection; finite difference approximation; heat transfer; *NBSIR 82-1660*.

natural material; radioactivity; radionuclide; standard; traceability; calibration; environment; *SP609*; 1982 February. 117-127.

natural-matrix reference materials; radioactivity measurements; radiopharmaceuticals; traceability; environmental measurements; international quality assurance; national quality assurance; *20883*.

natural ventilation; building energy analysis; computer simulation; infiltration; *21123*.

natural ventilation; psychological needs; view out; window; window management; control; daylight; energy balance; *21043*.

natural weathering; solar collectors; solar energy; solar energy transmittance; tensile properties; weathering of cover plates; artificial weathering; cover plate materials; durability; *TN1170*.

Naval Observatory; navigation; observatory; time; time ball; time dissemination; *21023*.

Na vapor; sodium *K* absorption; heat-pipe furnace; *21329*.

Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; *20836*.

navigation; observatory; time; time ball; time dissemination; Naval Observatory; *21023*.

Navy nontactical data processing; performance management strategy; capacity management; computer performance evaluation; *SP500-95*; 1982 October. 65-74.

NBS; solar; solar domestic hot water system; stratification; test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; *BSS140*.

NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; transactions; annual reports; diffusion in metals; fire; journals; library holdings; *NBSIR 82-2575*.

NBS periodicals; periodicals; proceedings; serials; standards; transactions; annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; *NBSIR 82-2575*.

NBS research capabilities; biomass conversion R&D; bioprocess engineering; biotechnology; chemical industry trends/strategies; commodity organic chemicals; measurement/evaluated data needs; *NBSIR 82-2549*.

NBS-6; primary standard; cavity phase shift; cesium clock; frequency standard evaluation; frequency standard uncertainties; *21251*.

NBS 80th Anniversary; productivity; science; software edge; fundamental research; Government-industry relationships; industrial technology; *SP627*.

NCSBCS; state; laboratory accreditation; local; *SP632*; 1982 March. 61-62.

Nd; Pr; Sm; Tb; wavelength; Ce; energy levels; Eu; Gd; Ho; *20877*.

NDE; neutron radiography; preventive maintenance; composite inspection; corrosion detection; cost savings; *SP640*; 1982 October. 417-453.

NDE; nickel base alloys; testing; defect detection; eddy current; failure prevention; ferro-magnetic alloys; inspection; metal distress; metal parts; *SP640*; 1982 October. 454.

Nd laser; photon-assisted transitions; angular distributions; close-coupling approximation;  $\text{CO}_2$  laser; elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; free-free transitions; *20787*.

nearest neighbor interactions; electron transfer; electron transfer model; interacting multiple redox centers; interaction energies; *20837*.

near-field measurements; standard antennas; antenna gain; antenna measurements; antenna pattern; antenna polarization; calibrations; *21200*.

near-field scanning application; offset; antenna; remote sensing of



atmosphere; corrugated feed; 21186.  
 nebulae, Orion Nebula; interstellar, molecules; line identifications; 20923.  
 necklace model; polystyrene; Aroclor; dynamic intrinsic viscosity; internal viscosity; 21059.  
 need; criteria; definitions; history; international trade; laboratory accreditation; SP632.  
 negative ions; Thomson Parabola charged particle analyser; magnetic insulating voltage measurement; SP628; 1982 June. 87-94.  
 negative molecular ions; Penning ionization source; mass spectrometry; 20907.  
 nematic liquid crystals; elasticity coefficients; 20822.  
 neodymium; samarium; spectrum; tantalum; tungsten; ytterbium; barium; dysprosium; energy levels; erbium; gadolinium; 20845.  
 net savings; solar energy computer program; solar energy economics; solar energy systems; computer simulation models; Federal Life-Cycle Cost Rules; life-cycle cost analysis; NBSIR 81-2379.  
 net space charge; corona discharge; HEPA filters; ion counters; ion density; ions; NBSIR 82-2486.  
 net space charge; electrostatic potential; high efficiency air particulate (HEPA) filters; ion counters; ion density; measurement; NBSIR 82-2517.  
 net space charge density; current density measurements; high efficiency particulate air filter; high voltage dc transmission lines; ion counter; ion density; NBSIR 82-2527.  
 network; performance; remote; response time; series/1; sidestreaming; simulated commands; 327X emulator; accurate data; end user; host independent; monitor; SP500-95; 1982 October. 401-407.  
 network; serial; broadcast; coaxial; communication; contention; data; digital; Ethernet; local; microprocessor; 20839.  
 network data model; access control; CODASYL; database management system; DBMS; NBS-GCR-82-370.  
 network data model; relational data model; schema design; database design; database management; database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; NBS-GCR-82-390.  
 networking performance; network protocols; protocol standards; standards; distributed computing; high level protocols; 21386.  
 network model analysis; queueing network models; software packages; SP500-95; 1982 October. 183-187.  
 network performance; performance evaluation; computer network; local networking; mathematical modeling; measurement; SP500-95; 1982 October. 389-396.  
 network protocols; protocol standards; standards; distributed computing; high level protocols; networking performance; 21386.  
 network protocols; standards; computer networks; Federal Information Processing Standards; International Organization for Standardization; local area networks; National Bureau of Standards; 21363.  
 networks; remote access of data; semantic integrity; constraint; database; database management system; data correctness; integrity; 21124.  
 network throughput; survivability; alternate routing; communications networks; distributed control; message delay; 20994.  
 neutral and ionic spectra; regularities; similarities; Stark broadening; isolated lines; 21365.  
 neutral traps; oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; NBSIR 81-2413.  
 neutrino oscillations; potentials; scaling; Fermion masses; internal spaces; mixing angles; 21168.  
 neutron; neutron radiography; nondestructive evaluation; nuclear reactor; radiation; activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; TN1160.  
 neutron; proton current; pulsed generators; pulsed power; voltage determinations; deuteron current; dielectric; SP628; 1982 June. 104-117.  
 neutron; remmeter; room return; air scatter; calibration; californium; dose equivalent; dosimeter; SP633.  
 neutron; restrained refinement; single crystals; x rays; joint refinement; macromolecular structures; 21136.  
 neutron activation; plasma; zinc; dietary enrichment; isotopes; mass spectrometry; 21374.  
 neutron beam design; neutron fission; uranium-235; ionization chamber; mass; 20814.  
 neutron calibration; neutron source; neutron spectroscopy; neutron spectrum; neutron time-of-flight; absolute neutron measurement; 21022.  
 neutron detector; neutron flux monitor; neutron standards; U-235 fission cross section; absolute fission cross section; 21135.  
 neutron diffraction; nondestructive evaluation; residual stress; stress analysis; x-ray diffraction; diffraction; high-energy x-rays; internal stress; 21359.  
 neutron diffraction; nondestructive evaluation; residual stress; stress measurements; ultrasonics; x-ray diffraction; Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; 20926.  
 neutron diffraction; powder method; Rietveld method; solid solution; tantalum oxide; lithium tantalate; 21157.  
 neutron diffraction; powder refinement; significant differences; statistical analysis; comparison of models; linear regression; 21401.  
 neutron diffraction; profile refinement; rare earths; crystal fields; ferromagnetism; manganese compounds; 20944.  
 neutron diffraction; spin waves; transition metals; amorphous materials; ferromagnetism; magnetization; 20945.  
 neutron dosimetry; optical waveguides; radiochromic dyes; anomalous dispersion; dimethyl sulfoxide; dosimetry; fibre optics; gamma-ray dosimetry; leuko cyanides; 20804.  
 neutron fission; uranium-235; ionization chamber; mass; neutron beam design; 20814.  
 neutron flux monitor; neutron standards; U-235 fission cross section; absolute fission cross section; neutron detector; 21135.  
 neutron imaging; neutron sources; pin-hole camera; position-sensitive proportional counter; associated particles; 21312.  
 neutron inelastic scattering; Raney nickel; vibrational spectroscopy; chemisorption; hydrogen; 21295.  
 neutron radiation effects; power transistors; radiation effects; semiconductor devices; VDMOS; drain-source resistance; electron devices; gamma radiation effects; MOSFETs; MOS power transistors; 21000.  
 neutron radiography; nondestructive evaluation; nuclear reactor; radiation; activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; TN1160.  
 neutron radiography; preventive maintenance; composite inspection; corrosion detection; cost savings; NDE; SP640; 1982 October. 417-453.  
 neutron radiography; traceable NDE; visual acuity; acoustic emission; eddy currents; leak rate measurements; liquid penetrants; magnetic particles; 21166.  
 neutrons; photons; standard; testing program; conversion factors; dose equivalent; field measurement; Health Physics Society; 20813.  
 neutrons; position-sensitive detectors; precision of data; x rays; diffractometry; macromolecular crystallography; 20982.  
 neutrons; standardization; calibration; SP609; 1982 February. 39-43.  
 neutron scattering; niobium hydride; tritide; vibration spectra; defect; isotope; metal hydride; 20948.  
 neutron scattering; nitromethane; reorientation; tunnel states; deuterated; methyl group; 20895.  
 neutron scattering; phonon coupling; theory; hydrogen in metals; impurity tunneling; KBr:CN<sup>-</sup>; KCl:CN<sup>-</sup>; 20879.  
 neutron scattering; ternary superconductors; antiferromagnetic superconductors; chevrel-phase; ErRh<sub>4</sub>B<sub>4</sub>; ferromagnetic superconductors; 21131.  
 neutron source; neutron spectroscopy; neutron spectrum; neutron time-of-flight; absolute neutron measurement; neutron calibration; 21022.  
 neutron sources; pin-hole camera; position-sensitive proportional counter; associated particles; neutron imaging; 21312.  
 neutron spectroscopy; neutron spectrum; neutron time-of-flight; absolute neutron measurement; neutron calibration; neutron source; 21022.  
 neutron spectroscopy; niobium; tunneling; hydrogen in metals; impurities; inelastic structure factor; 20941.  
 neutron spectrum; neutron time-of-flight; absolute neutron measurement; neutron calibration; neutron source; neutron spectroscopy; 21022.  
 neutron standards; U-235 fission cross section; absolute fission cross section; neutron detector; neutron flux monitor; 21135.  
 neutron time-of-flight; absolute neutron measurement; neutron calibration; neutron source; neutron spectroscopy; neutron spectrum; 21022.  
 newspaper recovery; North Carolina; resource recovery; South Carolina; cellulosic insulation; Florida; Georgia; NBS-GCR-82-371.  
 Newtonian gravitational constant; gravitational constant; 20968.



New York City; resource recovery; solid waste management; steam production; destruct heating; electricity production; energy recovery; incineration; *NBS-GCR-82-409*.

NHTSA; safety-related defects; safety standards; auto safety hotline; defects; motor vehicle equipment; motor vehicles; *SP621*; 1982 October. 212-214.

NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; 20825.

nickel resistors; semiconductor devices; dew point; failure; hybrid microcircuit; moisture; *SP400-72*; 1982 April. 175-177.

nickel; electron energy-loss spectra; incident-energy dependence; 20860.

nickel; ELS; energy loss spectroscopy; Fano effect; 21390.

nickel; photoelectrons; surface analysis; Auger electrons; copper; gold; 20986.

nickel; temperature programmed desorption; carbon monoxide; chemisorption; isotopic exchange; 20863.

nickel adhesion; plating; aluminum; anodizing; electrodeposition; 21267.

nickel base alloys; testing; defect detection; eddy current; failure prevention; ferro-magnetic alloys; inspection; metal distress; metal parts; NDE; *SP640*; 1982 October. 454.

nickel nitrate; osmotic coefficient; solubility; solutions; thermodynamics; activity coefficient; electrolyte; excess Gibbs energy; isopiestic; 21234.

nickel-phosphorus; steel; wear; wear testing; chromium; coatings; electrodeposition; metallic glasses; 21232.

nickel-phosphorus alloy; ultra-black coating; electroless nickel plating; *U.S. Patent 4,361,630*.

night space cooling; night ventilation; passive solar heating; building thermal mass; dynamic performance of buildings; energy conservation; heat transfer in buildings; *BSS137*.

night ventilation; passive solar heating; building thermal mass; dynamic performance of buildings; energy conservation; heat transfer in buildings; night space cooling; *BSS137*.

niobium; optical constants; reflectance; refractive index; dielectric constants; ellipsometry; 21183.

niobium; spectra; strontium; vacuum ultraviolet; yttrium; zirconium; molybdenum; 21179.

niobium; superconductor; tin; titanium; copper; critical current; electrical property; magnetic field; measurement; 21218.

niobium; tunneling; hydrogen in metals; impurities; inelastic structure factor; neutron spectroscopy; 20941.

niobium hydride; tritide; vibration spectra; defect; isotope; metal hydride; neutron scattering; 20948.

nitinol sensor; on-board failure detection system; overheated bearings; thermal switch sensor; train line; contact derailment sensor; g-sensing derailment detector; local derailment; *SP621*; 1982 October. 49-68.

nitric acid; rate constant; resonance fluorescence; stratospheric ozone; chemical kinetics; flash photolysis; hydroxyl radicals; 21040.

nitrobenzene; partial discharges; streamers; transient phenomena; electrical breakdown; high speed photography; Kerr effect; liquid breakdown; 21328.

nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties; argon; critically evaluated data; density; ethylene; heat capacity; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; enthalpy; equation of state; ethylene; hydrogen; *TN1048*.

nitrogen; numerical calculation; transport; diffusion; drift velocity; electrons; excitation; 21002.

nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; *NSRDS-NBS72*.

nitrogen; physical acoustics; precondensation; propane; sorption; speed of sound; velocity of sound; acoustical measurements; acoustic resonator; adsorption; 21230.

nitrogen; sodium; line broadening; 20871.

nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; thermophysical properties; argon; critically evaluated data; density; ethylene; heat capacity; nitrogen; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

nitrogen trifluoride; oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; enthalpy; equation of state; ethylene; hydrogen; *TN1048*.

nitrogen-15; nitrogen-15 chemical shifts; nitrogen-15-proton coupling constants; n.m.r. spectroscopy; ascorbic acid derivatives; bis(phenylhydrazones); 21084.

nitrogen-15 chemical shifts; nitrogen-15-proton coupling constants; n.m.r. spectroscopy; ascorbic acid derivatives; bis(phenylhydrazones); nitrogen-15; 21084.

nitrogen-15-proton coupling constants; n.m.r. spectroscopy; ascorbic acid derivatives; bis(phenylhydrazones); nitrogen-15; nitrogen-15 chemical shifts; 21084.

nitromethane; photolysis; force constants; gas phase; infrared spectrum; matrix isolation; methyl-*d*<sub>3</sub> nitrite; methyl nitrite; 21302.

nitromethane; reorientation; tunnel states; deuterated; methyl group; neutron scattering; 20895.

Ni(100); carbon monoxide; catalytic activity; dissociation; hydrogen; iron; 20987.

Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; 20825.

Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); 20825.

N-methylpyridinium iodide; pyridine derivatives; Raman spectroscopy; silver electrode; surface-enhanced Raman spectroscopy; adsorption; electrode processes; 21262.

NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; *NBSIR 81-2424*.

n.m.r. spectroscopy; ascorbic acid derivatives; bis(phenylhydrazones); nitrogen-15; nitrogen-15 chemical shifts; nitrogen-15-proton coupling constants; 21084.

noise; acousto-optic; bandshape; bandwidth; broadening; laser; modulation; 21375.

noise; photon detector; rectifier; solid state devices; transistor; electronics; *TN1169*.

noise thermometers; nonlinear differential equation; superconductivity; Josephson junctions; 21049.

noise thermometry; nuclear orientation thermometry; superconductors; temperature fixed points; thermodynamic temperature; thermometry; tunnel diode oscillators; low-temperature gases; 21018.

nonaqueous; thin layer spectroelectrochemistry; vacuum; methyl viologen; 20872.

nondestructive evaluation; nondestructive testing; scattering; variational method; elastic waves; flaws; 21239.

nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; 21223.

nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; 21236.

nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; weld evaluation; mechanical properties; 21242.

nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; welding evaluation; mechanical properties; 21235.

nondestructive evaluation; nuclear reactor; radiation; activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; neutron radiography; *TN1160*.

nondestructive evaluation; optics; penetrants; radiography; and ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; *NBSIR 82-2449*.

nondestructive evaluation; penetrant test block; traceable measurements; ultrasonic reference blocks; ultrasonic transducers; x-ray magnifier; acoustic emission simulator; acoustic emission transducers; 21181.

nondestructive evaluation; photoelasticity; research needs; residual stress; standards; stress measurement; terminology; ultrasonics; x-ray diffraction; fatigue; hole drilling; 21344.

nondestructive evaluation; pipeline; radiography; regulation; defect size measurement; fracture mechanics; girth welds; 21189.

nondestructive evaluation; pipeline safety; reactor safety; reliability;



risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; 21177.

nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; valve; database; data collection; failure data; inservice data; inservice inspection; mechanical component; 21176.

nondestructive evaluation; radiography; standards; traceable measurements; visual testing; acoustic emission; calibration; leak rate measurements; liquid penetrants; magnetic particles; 21398.

nondestructive evaluation; radiography; tire inspection; ultrasonics; visual-optical; acoustic emission; eddy currents; liquid penetrants; magnetic particles; microwaves; 20957.

nondestructive evaluation; Rayleigh wave; transducer; ultrasonic; acoustic emission; elastic wave; 21098.

nondestructive evaluation; residual stress; stress analysis; x-ray diffraction; diffraction; high-energy x-rays; internal stress; neutron diffraction; 21359.

nondestructive evaluation; residual stress; stress measurements; ultrasonics; x-ray diffraction; Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; 20926.

nondestructive evaluation; scattering; ultrasonic waves; variational method; acoustic waves; cracks; finite element method; 21229.

nondestructive evaluation; stainless steel; ultrasonic scattering; ultrasonic waves; acoustic waves; elastic anisotropy; 21224.

nondestructive evaluation; titanium plate; titanium welds; ultrasonic C-scan; ultrasonic velocity; weld porosity; *NBSIR 82-2500*.

nondestructive inspection; quality control; welded steel bridges; fracture control; *SP621*; 1982 October. 130-142.

nondestructive testing; pultrusions; standards; composite materials; damage; fatigue; guys; mechanical testing; 21195.

nondestructive testing; quality assurance; building materials; concrete; evaluation; inplace testing; inspection; *J. Res.* 87(5): 407-438; 1982 September-October.

nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; *NBS-GCR-80-204*.

nondestructive testing; scattering; variational method; elastic waves; flaws; nondestructive evaluation; 21239.

nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; 21223.

nondestructive testing; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; 21236.

nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; weld evaluation; mechanical properties; nondestructive evaluation; 21242.

nonequilibrium dynamics; vortex viscosity; fast transport coefficients; Kubo-Green relation; 21238.

nonequilibrium molecular dynamics; nonlinear phenomena; phase changes; stability criteria; thermodynamics of the steady state; computer simulation; Couette flow; Lennard-Jones fluid; 20959.

nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; radial distribution function; shear; soft sphere fluid; viscosity; computer simulation; fluid structure; 21237.

nonequilibrium phase transitions; nonlinear optics; optical bistability; second harmonic generation; self pulsing; subharmonic generation; dispersive bistability; fluctuations; 20918.

nonequilibrium phenomena; nonNewtonian viscosity; statistical mechanics; Kirkwood-Smoluchowski equation; liquids; 20970.

nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; 20836.

non-ergodic; relaxation; velocity autocorrelation; distribution functions; hard rods; molecular dynamics; 21283.

nonferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles; directory; ferrous metals; glass; *NBS-GCR-82-366*.

nonflaming combustion; test method; toxicity; combustion products; flaming combustion; inhalation; materials; *NBSIR 82-2532*.

nonhydrogenic states; polaron; polyacetylene; soliton; doping; impurity states; midgap absorption; 21104.

nonionizing; radiation; radiofrequency; regulation; safety; standards; bioeffects; dosimetry; electromagnetic; exposure; 21038.

nonionizing radiation; nuclear medicine; radiation therapy; data handbook; diagnostic radiology; general physics; medical physics; *H138*.

nonlinear; relaxation; supercooling; Suzuki's scaling; time-dependent growth rate; unstable; 21399.

nonlinear analysis; perturbation theory; coupled nonlinear oscillators; 21117.

nonlinear convection; numerical integration; transient fluid motion; transient heat transfer; compressible fluid motion; convection; finite difference approximation; heat transfer; natural convection; *NBSIR 82-1660*.

nonlinear differential equation; superconductivity; Josephson junctions; noise thermometers; 21049.

nonlinear optics; optical bistability; second harmonic generation; self pulsing; subharmonic generation; dispersive bistability; fluctuations; nonequilibrium phase transitions; 20918.

nonlinear oscillations; normalization; representation theory; generalized inverses; Hamiltonian mechanics; Lie algebras; *NBSIR 82-2541*.

nonlinear phenomena; phase changes; stability criteria; thermodynamics of the steady state; computer simulation; Couette flow; Lennard-Jones fluid; nonequilibrium molecular dynamics; 20959.

nonlinear spectroscopy; phase conjugation; argon; laser spectroscopy; 21162.

nonlocal process; surface conductivity; surface phenomena; adsorbed water; electrical conductivity; *SP400-72*; 1982 April. 149-164.

nonNewtonian viscosity; statistical mechanics; Kirkwood-Smoluchowski equation; liquids; nonequilibrium phenomena; 20970.

nonresidential; residential; scenario; smoldering; cigarettes; codes; escape; fatalities; fire; flaming; flashover; 20775.

nonresonant; atomic sodium; high power laser; ionization; multiphoton; 21003.

normal alkanes; Raman microprobe; Raman spectroscopy; vibrational analysis; hexagonal urea lattice; inclusion compounds; microanalysis; 20996.

normal butane; orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; *Monogr.* 169.

normalization; representation theory; generalized inverses; Hamiltonian mechanics; Lie algebras; nonlinear oscillations; *NBSIR 82-2541*.

normal pressure effects; orientational distortion; radial distribution function; shear; soft sphere fluid; viscosity; computer simulation; fluid structure; nonequilibrium molecular dynamics; 21237.

normal spectral emittance; pulse heating; radiance temperature; tungsten; melting; 21227.

North Carolina; resource recovery; South Carolina; cellulosic insulation; Florida; Georgia; newspaper recovery; *NBS-GCR-82-371*.

notation conventions; rotational line strengths; transition moments; diatomic molecules; intensity factor; 21274.

notification program; standards code; trade; foreign regulations; GATT; 21145.

NQR thermometers; rhodium-iron thermometers; thermistors; EPT-76; germanium resistance thermometers; IPTS-68; magnetic thermometers; 20933.

NRC; pilot study; sources; standard; traceability; dosimeters; *SP609*; 1982 February. 145-148.

NRC; radiation measurements; regulations; regulatory guides; traceability; enforcement; inspections; *SP609*; 1982 February. 129-133.

nuclear effects simulation; particle beam technology; pulse power; transients; voltage measurements; current measurement; electrical measurements; electromagnetic pulse; fusion; *SP628*.

nuclear magnetic moment; nuclear orientation; nuclear quadrupole moment;  $\gamma$ -ray anisotropy thermometry;  $\gamma$ -ray transitions in  $^{166}\text{Er}$ ;  $^{166}\text{Ho}$ ; mixing ratios; 20978.

nuclear magnetism; nuclear orientation;  $\gamma$  rays;  $^{166}\text{mHo}$ - $^{166}\text{Ho}$  atomic magnetism; helical spin structure; holmium single crystal; low temperature; magnetic spin structure; 21017.

nuclear medicine; radiation therapy; data handbook; diagnostic radiology; general physics; medical physics; nonionizing radiation;



- nuclear orientation; nuclear quadrupole moment;  $\gamma$ -ray anisotropy thermometry;  $\gamma$ -ray transitions in  $^{166}\text{Er}$ ;  $^{166m}\text{Ho}$ ; mixing ratios; nuclear magnetic moment; 20978.
- nuclear orientation;  $\gamma$  rays;  $^{166m}\text{Ho}$ -Ho atomic magnetism; helical spin structure; holmium single crystal; low temperature; magnetic spin structure; nuclear magnetism; 21017.
- nuclear orientation thermometry; superconductors; temperature fixed points; thermodynamic temperature; thermometry; tunnel diode oscillators; low-temperature gases; noise thermometry; 21018.
- nuclear quadrupole moment;  $\gamma$ -ray anisotropy thermometry;  $\gamma$ -ray transitions in  $^{166}\text{Er}$ ;  $^{166m}\text{Ho}$ ; mixing ratios; nuclear magnetic moment; nuclear orientation; 20978.
- nuclear reactor; radiation; activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; *TN1160*.
- Nuclear Regulatory Commission; government operated; laboratory accreditation; *SP632*; 1982 March. 63-64.
- nuclear response function; nuclei; nucleons; quasi-free; charge magnetization; Coulomb sum rule; electron scattering; Fermi gas model; 21400.
- nuclear safeguards; plutonium dioxide; water determination; automatic titration; Karl Fischer reagent titration; moisture; *NBSIR 82-2496*.
- nuclear shell effects; quartetting; supermultiplets; atomic masses; binding energies; mass formula; 20939.
- nuclear spin; rovibronic species; statistical weights; symmetric top molecules; group theory; 21300.
- nuclear waste; trace elements. nuclear waste; trace elements; chemical blank; contamination control; leachates; leach testing; 21372.
- nuclear waste; underground; alloys; containers; corrosion; corrosion data; geothermal brines; metals; *NBSIR 81-2409*.
- nuclear weapons; bremsstrahlung radiation; Casino Facility; effects simulator; *SP628*; 1982 June. 118-132.
- nucleating agent; phase change storage; service life prediction; crystal growth; encapsulants; failure mechanisms; *NBSIR 81-2422*.
- nucleation; recalescence; solidification; undercooling; amorphous; cooling rate; crystalline; dendrites; interfaces; microcrystalline; 21090.
- nuclei; nucleons; quasi-free; charge magnetization; Coulomb sum rule; electron scattering; Fermi gas model; nuclear response function; 21400.
- nucleon; pair correlation function; resolution; solid angle; spectrometer; momentum acceptance; 21402.
- nucleons; quasi-free; charge magnetization; Coulomb sum rule; electron scattering; Fermi gas model; nuclear response function; nuclei; 21400.
- nucleus; photon; pion; electron; Fermi gas model; Feynman diagrams; meson exchange current; 21345.
- null experiments; relativity; Eötvös experiment; fibers; general relativity; gravitation; 20954.
- number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; 20955.
- numerical calculation; transport; diffusion; drift velocity; electrons; excitation; nitrogen; 21002.
- numerical correction; analog-to-digital converters; error caused by response time; impulse measurements; *SP628*; 1982 June. 341-354.
- numerical integration; transient fluid motion; transient heat transfer; compressible fluid motion; convection; finite difference approximation; heat transfer; natural convection; nonlinear convection; *NBSIR 82-1660*.
- numerical methods; unsteady flow; vortex shedding; computer simulation; external aerodynamics; fluid dynamics; mathematical modeling; 21044.
- numeric data files; software summary; ANSI Z39.2; bibliographic control; FIPS 30; format structure; machine-readable cataloging; machine-readable data files; MARC; MRDF; *SP500-94*; 1982 October. 189-196.
- nursing homes; optimization; renovation; applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; 20909.
- nursing homes; panic; smoke detectors; sprinkler systems; bibliographies; evacuation; fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; *NBSIR 81-2438*.
- nursing homes; room fires; smoldering; fabric flammability; fire models; fire tests; home fires; hospitals; mattresses; *NBSIR 81-2440*.
- nutrients; SRM's; stability; vitamins; food matrices; methods of measurement; *SP635*.
- NVLAP; testing; commercial laboratories; concrete; laboratory accreditation; *SP632*; 1982 March. 54-56.
- NVLAP system; United States; accrediting laboratories; international; *SP632*; 1982 March. 92-98.
- nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosanine; leucocyanide dyes; 20905.

## O

- objectives; purpose; facility design; future plans; implementation; *SP609*; 1982 February. 77-79.
- observatory; time; time ball; time dissemination; Naval Observatory; navigation; 21023.
- occupational monitoring; optical microscopy; analysis; asbestos; electron microscopy; *SP619*; 1982 March. 132-137.
- occupational radiation protection standards; performance criteria; quality control; radiation instrument performance; radiation measurements; regulatory standards; accuracy; bioassay performance; *SP609*; 1982 February. 149-169.
- OCR; optical character recognition; character shapes; data entry; Federal Information Processing Standard; graphic shapes; magnetic ink characters; MICR; MICR Read Optically; *FIPS PUB 32-1*.
- octacalcium phosphate; sodium urate; biomaterials; calcium carbonates; calcium oxalates; calcium phosphates; calcium pyrophosphate; crystal structures; hydroxyapatite; 21110.
- octanol/water partition coefficients; activity coefficients; alkylbenzenes; gas chromatography; *J. Res. 87(4)*: 311-315; 1982 July-August.
- octanol/water partition coefficients; solubility parameters; activity coefficients; gas chromatography; *J. Res. 87(2)*: 155-158; 1982 March-April.
- octylins; poly(vinyl chloride); diffusion; extraction; food packaging; heat stabilizers; migration; 21325.
- octylins; organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; *NBSIR 81-2314*.
- office-building; radiant; solar; space-heating; air-cooling; air leakage; energy; heat-recovery; insulation; measurement; 20961.
- office building; thermal response; ventilation; air conditioning; air distribution; building systems; computer; control; modeling; 21047.
- offset, antenna; remote sensing of atmosphere; corrugated feed; near-field scanning application; 21186.
- offsets; administrative experiment; air pollution; emissions trading; ETIP; innovation; *NBSIR 82-2475*.
- oil recycling; petroleum; pollution control; reclaiming; re-refining; used oil; waste oil; lubricants; 21383.
- oil shale retorting; organometallics; process waters; shale oil; speciation; arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; 21125.
- oil supply models; resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; *SP631*.
- Oklahoma; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-350*.
- olfaction; protein separation; chemical analysis; electrochemistry; membranes; *NBS-GCR-82-378*.
- oligomers; polyethylene; polypropylene; radiotracer; antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; *NBSIR 82-2472*.
- OMNITAB 80; overlay; segmentation; system parameters; transportable computer software; ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; *TN1163*.
- on-board failure detection system; overheated bearings; thermal switch sensor; train line; contact derailment sensor; g-sensing derailment detector; local derailment; nitinol sensor; *SP621*; 1982 October. 49-68.
- on-condition maintenance; oscillation viscometry; atomic emission spectroscopy; cost-effective; data processing; infrared



spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); *SP640*; 1982 October. 61-71.

on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; *SP640*; 1982 October. 235-254.

on-going monitoring activity; package-sealing environment; aluminum oxide; Cerdip packages; IC assembly; in-situ moisture sensors; LSI circuits; mass spectrometry; *SP400-72*; 1982 April. 113-116.

on-line documentation; authoring; human interface; *SP500-94*; 1982 October. 236-241.

on-line sequential liquid chromatographic analysis; polynuclear aromatic hydrocarbons; shale oil analysis; solvent refined coal; determination of benzo[a]pyrene; multidimensional chromatographic analysis; *20981*.

on-line system; system performance; flow of information; *SP500-95*; 1982 October. 41-45.

open-circuit voltage decay; surface recombination velocity; electrical test structure; gated diode; generation lifetime; integrated gated-diode electrometer; integrated test structure; leakage current; *21143*.

open dating; packaging and labeling; registration of servicepersons; unit pricing; Weighmaster Law; basic weights and measures law; method of sale of commodities; *H130*, 1983 Edition.

open-field site; transverse electromagnetic cells; electromagnetic radiated emissions measurements; *21062*.

opening flows; air flows; compartment fires; entrainment; fire plumes; flow rates; *NBSIR 82-2520*.

openings; plume; room fire; entrainment; flame angle; *20810*.

operating system capabilities; operating systems; database management; databases; database system features; database systems; *NBS-GCR-82-393*.

operating systems; database management; databases; database system features; database systems; operating system capabilities; *NBS-GCR-82-393*.

operating temperature; poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; *SP640*; 1982 October. 257-274.

operational environment; preventive maintenance; wear; corrosion; failure prevention; human performance; material and material processing; mechanical and structural failure; *SP640*; 1982 October. 2-16.

operation phase; software documentation; systems life cycle; systems management; *SP500-94*; 1982 October. 58-67.

operations manual; real-time system; documentation; *SP500-94*; 1982 October. 53-57.

operations phase; automated data systems; computer programs; documentation; Federal Information Processing Standards (FIPS); *SP500-94*; 1982 October. 68-75.

operative temperature; passive solar; temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; *NBSIR 81-2393*.

opposed flow; solid fuel; Damkohler number; flame spread; gas phase; heat transfer; laminar flame; Laser Doppler Velocimeter; *NBS-GCR-82-388*.

optical bistability; second harmonic generation; self pulsing; subharmonic generation; dispersive bistability; fluctuations; nonequilibrium phase transitions; nonlinear optics; *20918*.

optical character recognition; character shapes; data entry; Federal Information Processing Standard; graphic shapes; magnetic ink characters; MICR; MICR Read Optically; OCR; *FIPS PUB 32-1*.

optical communications; optical waveguides; fiber optics; *H140*.

optical constants; reflectance; refractive index; dielectric constants; ellipsometry; niobium; *21183*.

optical density; test methods; visibility; correlation; fire tests; full-scale; smoke; smoke density chamber; *NBSIR 82-2508*.

optical fiber; attenuation; backscatter; bandwidth; index profile; measurements; *SP637, Volume 1*.

optical fiber scattering; optical time-domain reflectometer; OTDR; backscattering; backscatter signatures; *TN1050*.

optical frequency standard; stored ions; atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; microwave frequency standard; *21202*.

optical frequency standards; laser frequency standards; laser stability; *21001*.

optical heterodyne spectroscopy; precision laser spectroscopy; FM spectroscopy; laser frequency control; *21170*.

optical levitation; particle sizing; polarization ratio; radiation pressure; resonances; light scattering; liquid droplets; microspheres; Mie theory; *21054*.

optical method; sprayed insulation; asbestos; bulk material; laboratory evaluation; *SP619*; 1982 March. 44-52.

optical microscope; photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; *SP400-74*.

optical microscopy; analysis; asbestos; electron microscopy; occupational monitoring; *SP619*; 1982 March. 132-137.

optical path-length correction; phase comparator; real-time control; vibration control; vibration isolation; active vibration control; Michelson interferometer; *21403*.

optical properties; photoluminescence; silicon; bound exciton; density of states; indium doped silicon; isoelectronic; *21146*.

optical properties; silicon; sulfur; chemical interactions; deep-level measurements; defects; *20842*.

optical pumping; atomic beam; hydrogen; metastable states; *21102*.

optical pumping; atomic frequency standard; laser diode; laser stabilization; light shift; *21210*.

optical pumping; rubidium beam; rubidium cell; rubidium frequency standard; atomic frequency standard; laser frequency standard; *21203*.

optical radiation measurements; radiometry; solar radiation; spectroradiometry; UV spectral measurements; atmospheric attenuation; atmospheric ozone; *TN910-5*.

optical reflections; reflection coefficient; Riccati equation; surface reflections; wave impedance; electromagnetic waves; graded materials; inhomogeneous media; jellium; *TN1171*.

optical spectra; phonons; Raman spectra; silicon; spectra; thermal annealing; annealing; boron; ion implantation; laser annealing; local mode; *21091*.

optical time-domain reflectometer; OTDR; backscattering; backscatter signatures; optical fiber scattering; *TN1050*.

optical transmittance; refractive index; scattering matrix; thin film; transmittance extrema; electro-optic modulation; hydrogenated amorphous silicon; *NBSIR 81-1652*.

optical waveguides; fiber optics; optical communications; *H140*.

optical waveguides; radiochromic dyes; anomalous dispersion; dimethyl sulfoxide; dosimetry; fibre optics; gamma-ray dosimetry; leuko cyanides; neutron dosimetry; *20804*.

optic phonon; oscillator strength; photoelastic; piezobirefringence; dispersion; effective charge; GaAs; gallium arsenide; infrared elasto-optic; *21085*.

optics; penetrants; radiography; and ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; *NBSIR 82-2449*.

optimal memory allocation; stochastic control theory; memory management; *SP500-95*; 1982 October. 155-172.

optimal weatherization; Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; *NBSIR 82-2539*.

optimal weatherization; residential energy consumption; weatherization; Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; *BSS144*.

Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; energy related data; field measurement of building energy use; *TN1156*.

optimization; renovation; applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; *20909*.

optimal requirements; procurement; relational; standards; database management; DBMS; functional specification; mandatory



requirements; *NBS-GCR-82-372*.

optoelectronic measurement system; simulated kickback motion; volunteer test subjects; chain saw kickback motion; displacement measurements; kickback energy; *NBSIR 82-2559*.

optogalvanic; two photons; energy transfer; flames; ionization; multiphoton; *21132*.

orbit calculations; algebra of series; celestial mechanics; *20806*.

order statistics; statistical methods; acceptance probability; compliance sampling; dual acceptance criteria; mixed sampling plan; *J. Res. 87(6): 485-511; 1982 November-December*.

ordinary differential equation solution; parabolic cylinder functions; titration; chemical kinetics solution; kinetic titrimetry; *20912*.

organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; adsorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; *TN1150*.

organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; NMR; *NBSIR 81-2424*.

organometallics; process waters; shale oil; speciation; arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; *21125*.

organotin cations; speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; *21272*.

organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; *20955*.

organotins; polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; *NBSIR 81-2314*.

orientational distortion; radial distribution function; shear; soft sphere fluid; viscosity; computer simulation; fluid structure; nonequilibrium molecular dynamics; normal pressure effects; *21237*.

orthobaric densities; propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; *Monogr. 170*.

orthobaric densities; sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; *TN1051*.

orthobaric densities; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; *Monogr. 169*.

orthography; bibliographic citations; capitalization practices; database; *SP500-94; 1982 October. 215-218*.

orthorhombic; surfaces; uranium; hydride; hydrogen; microscopy; *21021*.

oscillation viscometry; atomic emission spectroscopy; cost-effective; data processing; infrared spectrophotometry; integrated reporting system; maintenance management; mechanical and lubricant integrity; MIR (multiple internal reflectance); on-condition maintenance; *SP640; 1982 October. 61-71*.

oscillator noise modeling; power law spectra; time-domain stability; white noise; flicker noise; frequency stability; *21284*.

oscillator noise modeling; power law spectrum; time-domain stability; white noise; flicker noise; frequency-domain stability; frequency stability; *21209*.

oscillator sensor; pressure; pulsed oscillator; pulsed sensor; temperature; tunnel diode; tunnel diode oscillator; LC oscillator; *21064*.

oscillator strength; photoelastic; piezobirefringence; dispersion; effective charge; GaAs; gallium arsenid; infrared elasto-optic; optic phonon; *21085*.

oscillator strength; photoionization; Stark effect; autoionization; *21036*.

oscillator strengths; radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; *21185*.

oscillatory flow; phase dependent; ripple; sand; sea bed; stress; time dependent; unsteady; water tunnel; waves; drag; *21332*.

osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; *TN1150*.

osmotic coefficient; polyvalent electrolytes; thermodynamics properties; activity coefficient; correlation; critical evaluation; electrolyte theories; models; *20935*.

osmotic coefficient; potassium carbonate; solubility; solutions; thermodynamics; activity coefficient; electrolytes; excess Gibbs energy; isopiestic; *21233*.

osmotic coefficient; solubility; solutions; thermodynamics; activity coefficient; electrolyte; excess Gibbs energy; isopiestic; nickel nitrate; *21234*.

osmotic coefficient; solutions; thermodynamic properties; activity coefficient; critical evaluation; electrolyte; excess Gibbs energy; *20936*.

osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; *NBSIR 81-2356*.

osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; *TN1150*.

OTDR; backscattering; backscatter signatures; optical fiber scattering; optical time-domain reflectometer; *TN1050*.

outdoor environment; thermal comfort; bioclimatic chart; human comfort; indoor environment; *21004*.

outdoor exposures; simulated stagnation exposure; solar energy; absorptive coatings; accelerated laboratory exposures; degradation; *NBSIR 82-2583*.

outlier; process validation wafer; statistical analysis; two-dimensional arrays; wafer map; computer program; correlation coefficient; *NBSIR 82-2492*.

overall system efficiency; residential furnaces; room temperature; thermal response factors; thermostat control; burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; *20903*.

overhaul; productivity; vibration; balancing; diagnostics; faults; jet engines; monitoring; *SP640; 1982 October. 115-129*.

overheated bearings; thermal switch sensor; train line; contact derailment sensor; g-sensing derailment detector; local derailment; nitinol sensor; on-board failure detection system; *SP621; 1982 October. 49-68*.

overlay; segmentation; system parameters; transportable computer software; ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; *TN1163*.

overshoot; power semiconductors; reverse-bias second breakdown; testing; voltage; clamping; diode recovery; high power measurements; high voltage; *20849*.

overview; research; state-of-the-art; applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; *NBSIR 82-2505*.

overview; research and development; robot; state-of-the-art; applications; forecast; Japan; *NBSIR 82-2479*.

overview; sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; *21326*.

oxidation; oxygen; sulfite ion; sulfur dioxide; aqueous solution; bibliography; bisulfite ion; chemical kinetics; *SP630*.

oxidation; petroleum products; review; additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; *NBSIR 82-2490*.

oxidation; platinum surface; catalysis; chemiluminescence; CO; *20821*.

oxidation; reduction; terbium; glass; luminescence; melts; *21315*.

oxidation; reversible; salts; croconates; dicyanomethylene; electrochemical; electron-transfer; mechanism; *21103*.

oxidation; solubilization; automotive crankcase oils; bench test procedures; catalysts; correlation; dispersancy; engine sequence tests; hot tube; laboratory bench tests; *21279*.



oxide moisture sensors; hybrids; moisture measurement; *SP400-72*; 1982 April. 110-112.

oxide-semiconductor interface; test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; *NBSIR 81-2413*.

oxygen; parahydrogen; thermodynamic properties; thermophysical properties; argon; critically evaluated data; density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

oxygen; permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; *TN1150*.

oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; ESD; *20832*.

oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; water; hydrogen; *21005*.

oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; hydrogen; methanol; methoxy; *21296*.

oxygen; pressure temperature; thermal conductivity; transient; hot wire; *J. Res. 87(4)*: 279-310; 1982 July-August.

oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; *NSRDS-NBS72*.

oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); *20825*.

oxygen; software; sorption; water; algorithms; calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; *SP400-72*; 1982 April. 3-7.

oxygen; specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; *TN1048*.

oxygen; sulfite ion; sulfur dioxide; aqueous solution; bibliography; bisulfite ion; chemical kinetics; oxidation; *SP630*.

oxygen consumption; room fires; calorimeters; fire tests; heat release rate; *NBSIR 81-2427-1*.

oxygen index test; fire modeling; fire retardancy; fire tests; flame retardancy; *21275*.

ozonation; thiolane; concerted reaction; cyclobutane; *20958*.

ozone; vapor phase reaction; carbocyclic compound; cyclic sulfide; *U.S. Patent 4,327,233*.

ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; *21254*.

ozone-alkene reactions; secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; *21255*.

ozone-olefin reactions; structure; air pollution; dioxirane; dipole moment; microwave spectrum; *21340*.

O<sub>2</sub>; Rydberg series; angular distributions;  $c^4\Sigma_u^-$  limit; electrons; experimental; inelastic scattering; *21077*.

## P

package reliability; sealing glass; Cerdip; integrated circuit packaging; internal water vapor; moisture evolution; *SP400-72*; 1982 April. 220-233.

packages; quality control; thermal shock; Cerdip; glass sealed; integrated circuit; *SP400-72*; 1982 April. 234-238.

package-sealing environment; aluminum oxide; Cerdip packages; IC assembly; in-situ moisture sensors; LSI circuits; mass spectrometry; on-going monitoring activity; *SP400-72*; 1982 April. 113-116.

packaging; reliability; standard packages; humidity; mass spectrometry; moisture sensors; *SP400-72*; 1982 April. 19-31.

packaging; water vapor; contamination; dew point; hermetic packages; moisture; *SP400-72*; 1982 April. 76-78.

packaging and labeling; pattern approval; specifications and

tolerances; technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; *SP629*.

packaging and labeling; registration of servicepersons; unit pricing; Weighmaster Law; basic weights and measures law; method of sale of commodities; open dating; *H130, 1983 Edition*.

packet switch; performance evaluation; simulation; trunk; WIN; analytical; capacity planning; central server; disk; main memory contention; modeling; *SP500-95*; 1982 October. 97-106.

packet switching survivability; alternate routing; circuit switching; communications networks; distributed control; integrated switching; *NBSIR 82-2588*.

Padé and integral approximants; renormalization group; Boson field theory; high-temperature series expansions; hyperscaling relations; Ising ferromagnet; *21080*.

paint manufacturing; resource recovery; solvent recovery; steel manufacturing; electroplating; Great Lakes region; hazardous waste management; *NBS-GCR-82-405*.

pair correlation function; resolution; solid angle; spectrometer; momentum acceptance; nucleon; *21402*.

palladium-copper-silicon alloys; rapid solidification; amorphous alloys; coupled growth; eutectic solidification; metallic glasses; *21190*.

panic; smoke detectors; sprinkler systems; bibliographies; evacuation; fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; *NBSIR 81-2438*.

paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles; directory; ferrous metals; glass; nonferrous metals; *NBS-GCR-82-366*.

paper; TAPPI; tenth anniversary; testing; Collaborative Reference Program; *21244*.

parabolic cylinder functions; titration; chemical kinetics solution; kinetic titrimetry; ordinary differential equation solution; *20912*.

parahydrogen; thermodynamic properties; thermophysical properties; argon; critically evaluated data; density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

parallax transformation; third-order solution; transformation; artificial satellite; Hamiltonian; *21381*.

parallel processing; scientific workload; vector processing; Amdahl's Law; benchmarking; computing environment; large-scale scientific computing; *SP500-95*; 1982 October. 121-126.

parameter estimator; PI-controller; recursive least squares algorithm; self-tuning control algorithm; adaptive control; air handling unit; direct digital control; energy management and control systems; HVAC system control; *NBSIR 82-2591*.

parametric tester; reliability; standard; test chip; test structure; custom; integrated circuits; multifunction; *20835*.

parametric testers; test methods; integrated circuits; microelectronic test chips; *20956*.

PAR factor; procurement; purchasing; recovered/recycled materials; resource recovery; bid-modifier; disposal costs; *NBS-GCR-82-400*.

partial differential equations; stream function; vorticity; buoyant convection; finite difference computations; fire-enclosure; fluid flow; Lanczos smoothing; *J. Res. 87(2)*: 165-185; 1982 March-April.

partial discharge; polydimethylsiloxanes; breakdown; electrical insulation; high voltage; liquids; *21130*.

partial discharge; transient phenomena; high voltage dividers; *SP628*; 1982 June. 69-79.

partial discharges; streamers; transient phenomena; electrical breakdown; high speed photography; Kerr effect; liquid breakdown; nitrobenzene; *21328*.

partially-filled pipe; slope; solid; stream-depth; surge; transport; velocity; water; equation; flow; horizontal; motion; *NBSIR 81-2450*.

particle beam fusion; peak gap voltage; voltage monitor; insulated transmission lines; magnetic insulation; multiterawatt accelerators; *SP628*; 1982 June. 80-86.

particle beam technology; pulse power; transients; voltage measurements; current measurement; electrical measurements; electromagnetic pulse; fusion; nuclear effects simulation; *SP628*.

particle board; fire models; fire tests; flame spread; ignition; *NBSIR 82-2557*.

particle size; pigment; computers; energy; instrumentation; *21013*.

particle size distribution; smoke; smoke detection; smoke production; smoldering; aerosol coagulation; combustion aerosols; *21231*.

particle sizing; polarization ratio; radiation pressure; resonances; light scattering; liquid droplets; microspheres; Mie theory; optical



levitation; 21054.

particle technologist; asbestos minerals; electron microscopical method; environment; EPA Provisional Methodology; *SP619*; 1982 March. 183-189.

particulate composites; wave propagation; composites; elastic constants; elastic-wave scattering; fiber-reinforced composites; 20884.

particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; *BSS138*.

particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; *BSS138*.

partition; degree sequence; graph; incidence sequence; loopless graph; *J. Res. 87(1)*: 75-78; 1982 January-February.

part-through crack; pipeline fracture; plastic necking instability; progressive crack growth; crack initiation; crack opening displacement; ductile fracture; leak vs. break; *SP621*; 1982 October. 153-164.

passive; physical; property; sensor; solar test building; cross-section; description; *NBS-GCR-82-398*.

passive design; solar energy; standards; building regulations; buildings; energy; enforcement; health and safety; *NBSIR 82-2554*.

passive films; potentiostat; anodic oxidation; dissolution of passive films; ellipsometry; iron; 20882.

passive solar; performance criteria; solar energy; thermal performance; active solar; evaluation process; hot water; *NBS-GCR-82-397*.

passive solar; temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; *NBSIR 81-2393*.

passive solar heating; building thermal mass; dynamic performance of buildings; energy conservation; heat transfer in buildings; night space cooling; night ventilation; *BSS137*.

passive solar systems; performance criteria; solar energy; standards; test procedures; code provisions; 21119.

passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; thermal comfort; ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; comfort envelope; human factors; *NBSIR 82-2585*.

passivity; pitting; corrosion; crevice corrosion; galvanic corrosion; implant materials; implants; 20881.

passivity; repassivation; surface modification; breakdown of passivity; corrosion; electrochemistry; 20928.

pattern approval; specifications and tolerances; technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; *SP629*.

pattern recognition; computerized-fingerprint-identification; identification; *SP500-89*.

pattern recognition; scene analysis; vision; vision systems; artificial intelligence; automation; computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; *NBSIR 82-2582*.

peak area; smoothing; spectroscopy; splines; statistical methods; linear models; minimax; *J. Res. 87(1)*: 53-65; 1982 January-February.

peak gap voltage; voltage monitor; insulated transmission lines; magnetic insulation; multiterawatt accelerators; particle beam fusion; *SP628*; 1982 June. 80-86.

peak management; water use patterns; *SP624*; 1982 June. 453-464.

pedestrian movement; regulatory process; simulation of human behavior; building codes; building fires; computer-aided design; computer simulation; emergency egress; fire research; human performance; modeling; 20911.

pedodontics; acid etch; adhesive bonding; composites; dental resins; fillers; 20915.

penetrants; radiography; and ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; *NBSIR 82-2449*.

penetrant test block; traceable measurements; ultrasonic reference blocks; ultrasonic transducers; x-ray magnifier; acoustic emission simulator; acoustic emission transducers; nondestructive evaluation; 21181.

penetration tests; practice; samplers; soil tests; standard penetration tests; drills; in situ test; 20867.

Penning ionization source; mass spectrometry; negative molecular ions; 20907.

Penning ion source; atomic negative ions; doubly charged ions; mass spectrometry; 21370.

Penning trap; quadrupole rf trap; atomic spectroscopy; ion trap; laser cooling; light pressure; 21011.

Pennsylvania; Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-351*.

peptides; amino acid analysis; anion-exchange; cytochrome c; enzymatic digestion; high-performance liquid chromatography; 21293.

peptides; angiotensins; anion-exchange; high-performance liquid chromatography; hormones; 21294.

perfect conductors; transient electromagnetic fields; wave equations; dyadic Green functions; electromagnetic scattering; integral equations; *TN1157*.

performance; remote; response time; series/1; sidestreaming; simulated commands; 327X emulator; accurate data; end user; host independent; monitor; network; *SP500-95*; 1982 October. 401-407.

performance analysis; solid waste; total energy; utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; *SP489*, Supplement 1.

performance criteria; photovoltaics; solar energy systems; standards; wind energy; biomass; heating and cooling; 21106.

performance criteria; project summaries; technical bases; building research; building technology; codes; criteria; measurement methods; *SP446-6*.

performance criteria; quality control; radiation instrument performance; radiation measurements; regulatory standards; accuracy; bioassay performance; occupational radiation protection standards; *SP609*; 1982 February. 149-169.

performance criteria; solar energy; standards; building; cooling; heating; hot water; *BSS147*.

performance criteria; solar energy; standards; buildings; cooling; heating; hot water; 21082.

performance criteria; solar energy; standards; test procedures; code provisions; passive solar systems; 21119.

performance criteria; solar energy; thermal performance; active solar; evaluation process; hot water; passive solar; *NBS-GCR-82-397*.

performance criteria for restoration coatings; porcelain enamel restoration; restoration coatings; accelerated bathtub exposure cycle; *NBSIR 82-2553*.

performance engineering techniques; software systems; *SP500-95*; 1982 October. 433.

performance evaluation; computer network; local networking; mathematical modeling; measurement; network performance; *SP500-95*; 1982 October. 389-396.

performance evaluation; performance measurement; performance prediction; VMAP; graphical presentation; IBM VM/SP; *SP500-95*; 1982 October. 331-359.

performance evaluation; performance modeling; queueing models; queueing networks; shared device; computer architecture; 20802.

performance evaluation; remote terminal emulation; remote terminal emulator; system under tests; interactive system; *SP500-95*; 1982 October. 409-413.

performance evaluation; remote terminal emulation; system design; teleprocessing systems; testing; external test driver; *SP500-95*; 1982 October. 415-421.

performance evaluation; simulation; trunk; WIN; analytical; capacity planning; central server; disk; main memory contention; modeling; packet switch; *SP500-95*; 1982 October. 97-106.

performance evaluation; simulation; UNIVAC systems; modeling; *SP500-95*; 1982 October. 231-257.

performance improvement plan; system performance indicators; computer performance evaluation; *SP500-95*; 1982 October. 75-80.

performance management strategy; capacity management; computer performance evaluation; Navy nontactical data processing; *SP500-95*; 1982 October. 65-74.

performance measurement; performance prediction; VMAP; graphical presentation; IBM VM/SP; performance evaluation; *SP500-95*; 1982 October. 331-359.

performance measurement; Shuttle Mission Simulator; UNIVAC; disk I/O; hardware monitoring; *SP500-95*; 1982 October. 217-230.



performance measurement data; software tuning; data tuning; modeling; MVS; *SP500-95*; 1982 October. 313-320.

performance measurements; embedded monitoring system; *SP500-95*; 1982 October. 191-194.

performance modeling; queueing model; queueing networks; approximate queueing model; computer architecture; *20969*.

performance modeling; queueing models; queueing networks; shared device; computer architecture; performance evaluation; *20802*.

performance/modeling data acquisition; software monitor; application of basic queueing theory; IBM's RMF; job class; mathematical modeling; *SP500-95*; 1982 October. 279-296.

performance monitoring; program analysis; program instrumentation; software tools; coverage analysis; dynamic analysis; *SP500-95*; 1982 October. 195-202.

performance prediction; queueing theory; UNIX; validation; *SP500-95*; 1982 October. 205-211.

performance prediction; VMAP; graphical presentation; IBM VM/SP; performance evaluation; performance measurement; *SP500-95*; 1982 October. 331-359.

performance standard; cable assembly; cable connector; control cable; control head; D-subminiature connector; interchangeability; law enforcement; microphone cable; mobile transceiver; *20904*.

performance standard; radiation pattern; relative antenna gain; antenna; base station; fixed antennas; law enforcement; *20901*.

performance standards; international standards; international test methods; national product standards; *21163*.

performance standards; police body armor; protective undergarments; armor; ballistic protection; ballistic threat; commercial body armor; *20906*.

performance test methods; emergency vehicle sirens; environmental tests; law enforcement; *20919*.

performance/thermal comfort; temperature drifts/comfort; thermal comfort; ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; *NBSIR 82-2585*.

periodical literature and documentation; software documentation; user's groups; verbal documentation; beginning computer users; documentation; hardware systems documentation; large computer manufacturers; microcomputers; *SP500-94*; 1982 October. 174-179.

periodicals; proceedings; serials; standards; transactions; annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; *NBSIR 82-2575*.

permeability; pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; *TN1150*.

permeation; permeation time-lag; SRM 1470; standard reference materials; automation; computer control; gas transmission; *21026*.

permeation time-lag; SRM 1470; standard reference materials; automation; computer control; gas transmission; permeation; *21026*.

personal computers; small computers; software; word processing; microprocessors; *NBSIR 82-2573*.

personnel/component/support shop functions; powerplant/component/support shop functions; aircraft maintenance functions; maintenance information systems functions; management and financial functions; master planning; material and logistics functions; *SP640*; 1982 October. 27-44.

personnel monitoring; reflected neutrons; scattered neutrons; background; calibration; californium neutrons; *20966*.

perturbation theory; coupled nonlinear oscillators; nonlinear analysis; *21117*.

perturbation theory; radiation; sodium atom; time development; transient effects; ionisation; linear polarization; monochromatic resonance; multiphoton; *21075*.

perturbation theory; singularity; x-ray edge; dispersion relation; *20960*.

perturbation theory; transport coefficient; transport properties; Boltzmann equation; collision integral; kinetic theory; *21197*.

petroleum; petroleum testing; processed used oil; recycled oil; burner fuel; fuel oil; *21394*.

petroleum; petroleum testing; recycled oil; re-refining; used oil recycling; additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; *21397*.

petroleum; pollution control; reclaiming; re-refining; used oil; waste oil; lubricants; oil recycling; *21383*.

petroleum oil; recycled oil; re-refined oil; test procedures; basestock; engine lubricants; lubricating oil; motor oil; *20990*.

petroleum products; review; additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; *NBSIR 82-2490*.

petroleum testing; processed used oil; recycled oil; burner fuel; fuel oil; petroleum; *21394*.

petroleum testing; recycled oil; re-refining; used oil recycling; additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; petroleum; *21397*.

pH; precipitation; rain; reference materials; trace elements; acidity; acid rain; chemical analysis; conductance; *NBSIR 82-2581*.

phase angle calibration; signal sampling; stability; waveform synthesis; ac-dc difference; data conversion; dynamic response; linearity; metrology support; *21027*.

phase changes; stability criteria; thermodynamics of the steady state; computer simulation; Couette flow; Lennard-Jones fluid; nonequilibrium molecular dynamics; nonlinear phenomena; *20959*.

phase change storage; service life prediction; crystal growth; encapsulants; failure mechanisms; nucleating agent; *NBSIR 81-2422*.

phase comparator; real-time control; vibration control; vibration isolation; active vibration control; Michelson interferometer; optical path-length correction; *21403*.

phase conjugacy; dipolar emission; *21321*.

phase conjugation; argon; laser spectroscopy; nonlinear spectroscopy; *21162*.

phase dependent; ripple; sand; sea bed; stress; time dependent; unsteady; water tunnel; waves; drag; oscillatory flow; *21332*.

phase diagram; properties; solid; crystal structure; hydrogen; *20979*.

phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; *SP260-77*.

phase measurements; power measurements; radiation pattern; TEM cell; total radiated power; dipole moments; electrically small; interference source; leakage; *TN1059*.

phase transition in polymers; polymer crystals; block copolymers; chain folding in polymers; copolymer; *21066*.

phenolic resin; specific heat; thermosetting polymers; varnishes; adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; *21032*.

phenyl; photodecomposition; 1-fluorocyclohexadienyl; benzene; F-atom reactions; infrared spectrum; matrix isolation; *20917*.

phonon coupling; theory; hydrogen in metals; impurity tunneling; KBr:CN; KCl:CN; neutron scattering; *20879*.

phonons; Raman spectra; silicon; spectra; thermal annealing; annealing; boron; ion implantation; laser annealing; local mode; optical spectra; *21091*.

phonons; two-dimensional systems;  $C_{36}K$ ; inelastic neutron scattering; intercalated systems; lattice dynamics; *20949*.

photo-absorption cross section; photochemistry; quantum yield; rate coefficient; air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; *JPCRD 11(2)*: 327-496; 1982.

photochemistry; picosecond; DNA; multiphoton; nanosecond; *21339*.

photochemistry; quantum yield; rate coefficient; air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photo-absorption cross section; *JPCRD 11(2)*: 327-496; 1982.

photodecomposition;  $CH_3$ ; formaldehyde;  $HNO$ ; hydrogen bonding; infrared spectrum; matrix isolation; methyl nitrite; *21301*.

photodecomposition; 1-fluorocyclohexadienyl; benzene; F-atom reactions; infrared spectrum; matrix isolation; phenyl; *20917*.

photodissociation;  $CH_3$ ;  $Hg(CH_3)_2$ ; laser; *21319*.

photodissociation; photofragmentation; methyl iodide ( $CH_3I$ ); methyl radical ( $CH_3$ ); *21114*.

photodissociation; photofragmentation; methyl iodide ( $CH_3I$ ); methyl radical ( $CH_3$ ); *21113*.

photodissociation; self-consistent field theory; ab initio; electronic structure; multiconfiguration; *21308*.

photoelastic; piezobirefringence; dispersion; effective charge; GaAs; gallium arsenide; infrared elasto-optic; optic phonon; oscillator strength; *21085*.

photoelasticity; research needs; residual stress; standards; stress measurement; terminology; ultrasonics; x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; *21344*.

photoelectron angular distributions; photon energy; Rydberg state; autoionizing resonances; *20870*.

photoelectron photoion coincidence; propylene; proton affinity; alkyl halide; breakdown curve; metastable transition; *21097*.



photoelectrons; surface analysis; Auger electrons; copper; gold; nickel; 20986.

photoelectron spectra; laser induced autoionizations; 21281.

photoelectron spectroscopy; surface science; synchrotron radiation; 21099.

photoelectron spectroscopy; photoionization; angular distributions; 21292.

photoelectron spectroscopy; photoionization; spectroscopy; appearance potential; charge transfer spectrum; electron impact ionization; ionization potential; *NSRDS-NBS71*.

photoelectron spectroscopy; photoionization; Xe; clusters; coincidence; mass spectrometry; 21153.

photoelectron spectroscopy; rare gases; synchrotron radiation; asymmetry parameter; autoionization; branching ratios; inner-shell resonances; 21291.

photoelectron spectroscopy; shape resonance; synchrotron radiation; autoionization; 21357.

photoelectron spectrum; superelastic collisions; associative ionization; energy pooling; lasers; 21221.

photoemission; relaxation; adsorption; many-body theory; 21151.

photofragmentation; methyl iodide ( $\text{CH}_3\text{I}$ ); methyl radical ( $\text{CH}_3$ ); photodissociation; 21114.

photofragmentation; methyl iodide ( $\text{CH}_3\text{I}$ ); methyl radical ( $\text{CH}_3$ ); photodissociation; 21113.

photofragmentation; photoionization; quantum yields; radiation chemistry; vacuum ultraviolet; charge recombination; cyclopentane; 21243.

photofragmentation; photolysis; ultraviolet;  $\text{Br}(^2\text{P}_{1/2})$ ;  $\text{I}(^2\text{P}_{1/2})$ ; laser; 20785.

photogrammetry; volume calibration; calibration accuracy; laser calibration; LNG ship tanks; *NBSIR 81-1655*.

photoionization; angular distributions; photoelectron spectroscopy; 21292.

photoionization; atoms; cross section; electron-ion pairs; electron shells; molecules; 21056.

photoionization; quantum yields; radiation chemistry; vacuum ultraviolet; charge recombination; cyclopentane; photofragmentation; 21243.

photoionization; resonance; ytterbium; Auger; core-holes; mixed-valence; 21105.

photoionization; spectroscopy; appearance potential; charge transfer spectrum; electron impact ionization; ionization potential; photoelectron spectroscopy; *NSRDS-NBS71*.

photoionization; Stark effect; autoionization; oscillator strength; 21036.

photoionization; synchrotron radiation; acetylene; angular distribution; 21006.

photoionization; Xe; clusters; coincidence; mass spectrometry; photoelectron spectroscopy; 21153.

photoluminescence; silicon; bound exciton; density of states; indium doped silicon; isoelectronic; optical properties; 21146.

photolysis; force constants; gas phase; infrared spectrum; matrix isolation; methyl- $d_3$  nitrite; methyl nitrite; nitromethane; 21302.

photolysis; radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; *NSRDS-NBS70*.

photolysis; ultraviolet;  $\text{Br}(^2\text{P}_{1/2})$ ;  $\text{I}(^2\text{P}_{1/2})$ ; laser; photofragmentation; 20785.

photomask; semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; *SP400-74*.

photomask; SRM; statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; *TN1164*.

photomask linewidth measurements; semiconductors; accurate measurements; benefit-cost analysis; cost savings; economic analysis; *NBSIR 82-2458*.

photon; pion; electron; Fermi gas model; Feynman diagrams; meson exchange current; nucleus; 21345.

photon; transport; bremsstrahlung; cross sections; data base; electron; 21384.

photon-assisted transitions; angular distributions; close-coupling approximation;  $\text{CO}_2$  laser; elastic and inelastic; electron-hydrogen scattering; Feshbach resonances; free-free transitions; Nd laser; 20787.

photon beam; radiation therapy; absorbed dose; calibration; electron beam; high energy; ionization chamber; 20894.

photon detector; rectifier; solid state devices; transistor; electronics; noise; *TN1169*.

photon detectors; SURF-II; calibration; electrons; instrumentation; 21053.

photon energy; Rydberg state; autoionizing resonances; photoelectron angular distributions; 20870.

photon flux; quantum yield; transfer standard; absolute calibration; absolute quantum yield; actimetry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; 21045.

photon probabilities per decay; relative photon-emission probabilities; compilation; efficiency data; half lives; measurement uncertainties; *SP626*.

photons; standard; testing program; conversion factors; dose equivalent; field measurement; Health Physics Society; neutrons; 20813.

photons; stopping power; transport; bremsstrahlung; cross sections; elastic scattering; electron-impact ionization; electrons; *NBSIR 82-2572*.

photon stimulated desorption; PSD; synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; ESD; oxygen; 20832.

photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; water; hydrogen; oxygen; 21005.

photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; hydrogen; methanol; methoxy; oxygen; 21296.

photonuclear research; polarized bremsstrahlung differential cross section; polarized photon beams; tagged photon method; Bethe-Heitler cross section; bremsstrahlung monochromator; *NBSIR 82-2454*.

photoresists; synchrotron radiation; energy deposition; extreme ultraviolet; high resolution; lithography; 21078.

photovoltaics; solar energy systems; standards; wind energy; biomass; heating and cooling; performance criteria; 21106.

physical; property; sensor; solar test building; cross-section; description; passive; *NBS-GCR-82-398*.

physical acoustics; precondensation; propane; sorption; speed of sound; velocity of sound; acoustical measurements; acoustic resonator; adsorption; nitrogen; 21230.

physical acoustics; propane; relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients; equation of state; ethylene; ideal gas heat capacity; 21208.

physical acoustics; summary; ultrasonics; bibliography; *NBSIR 82-2529*.

physical dimensions; analytical standards; asbestos standards; chemical composition; fibers; glass; *SP619*; 1982 March. 21-28.

physical modeling; room fires; scale models; fire growth; flashover; heat release rate; *NBSIR 81-2453*.

physical properties; Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; low-temperature; magnetic transition; 21198.

physical properties; reference data; chemical properties; critical tables; data evaluation; 21389.

physical properties; refractories; alloys; coal conversion; coal gasification; corrosion; erosion; materials properties; mechanical properties; *SP642*.

physical property; elastic constants; error propagation; matrix inversion; 20818.

physics classroom experiments; statistical consulting course; statistics; training; accuracies, comparison of; government careers; in-service training; 20947.

PI-controller; recursive least squares algorithm; self-tuning control algorithm; adaptive control; air handling unit; direct digital control; energy management and control systems; HVAC system control; parameter estimator; *NBSIR 82-2591*.

picosecond; DNA; multiphoton; nanosecond; photochemistry; 21339.

picosecond; pulse emission; streak-camera; tunable; dye laser; mode-locked; 21348.

pictograms; pictorial; safety; signs; standards; symbols; visual alerting; warning; communication; design issues; hazard; *BSS141*.

pictorial; safety; signs; standards; symbols; visual alerting; warning; communication; design issues; hazard; pictograms; *BSS141*.



piezobirefringence; dispersion; effective charge; GaAs; gallium arsenid; infrared elasto-optic; optic phonon; oscillator strength; photoelastic; 21085.

piezoelectric; polarization distribution; poling study; polyvinyl fluoride; pyroelectric; ferroelectric; 21245.

piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; 21392.

piezoelectricity; poling; pyroelectricity; tetrafluoroethylene; vinylidene fluoride; charge transport; copolymer; electrical properties; 20840.

piezoelectricity; polytrifluoroethylene; pyroelectricity; thermal expansion; chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; 21395.

piezoelectric polymer films; accelerometer; inertial mass; *U.S. Patent 4,315,433*.

piezoelectric polymers; polarization distribution; thermal pulse experiment; charge distribution; computer analysis; data reduction; Fourier analysis; 21155.

pigment; computers; energy; instrumentation; particle size; 21013.

pigment; protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; *TNI150*.

pilot study; sources; standard; traceability; dosimeters; NRC; *SP609*; 1982 February. 145-148.

pin and disc; restorative; wear; amalgam; apparatus; composite; dental; instrumentation; 20916.

pin-hole camera; position-sensitive proportional counter; associated particles; neutron imaging; neutron sources; 21312.

PIN transfer standards; pulse energy; pulse peak power; 1.064  $\mu$ m laser pulse measurements; APD transfer standards; beamsplitter attenuator; impulse response measurements; low-level laser measurements; modulated cw measurement system; *TNI058*.

pion; electron; Fermi gas model; Feynman diagrams; meson exchange current; nucleus; photon; 21345.

pipeline; plasticity; strength; stress; toughness; collapse; cracks; defects; failure; fracture mechanics; girth welds; 21169.

pipeline; radiography; regulation; defect size measurement; fracture mechanics; girth welds; nondestructive evaluation; 21189.

pipeline fracture; plastic necking instability; progressive crack growth; crack initiation; crack opening displacement; ductile fracture; leak vs. break; part-through crack; *SP621*; 1982 October. 153-164.

pipeline radiographic inspection; radiographic nondestructive testing; weld flaw inspection; flaw analysis from radiographs; flaw depth determinations; *SP621*; 1982 October. 165-173.

pipelines; rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; *SP621*.

pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; 21177.

pipes; potable water; pressure reduction; residential buildings; sprinkler systems; water; corrosion; friction reduction; *NBS-GCR-82-399*.

pipng; pressure vessel; pump; reliability; risk analysis; valve; database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; 21176.

piston gage; pressure difference; pressure transducer; standards; calibration; differential manometer; *TNI052*.

pitch of the pipe; plumbing drainage system; plumbing fixtures; transport mechanisms; transport phenomena; wall friction; building pipe drains; low water usage devices; *SP624*; 1982 June. 293-326.

pitting; accelerated testing; crevice corrosion; electrochemical techniques; localized corrosion; localized corrosion mechanism; *NBSIR 82-2477*.

pitting; corrosion; crevice corrosion; galvanic corrosion; implant materials; implants; passivity; 20881.

pitting; rolling element bearings; rolling fatigue; spalling; filtration; gearboxes; helicopter transmission; *SP640*; 1982 October. 326-347.

Pitzer's equations; *PVT*; volume; volumetric properties; apparent molal volume; aqueous sodium chloride solutions; compressibility; density; equation of state; expansivity; *JPCRD 11(1)*: 15-81; 1982.

planar; stationary; unshielded; chronoamperometry; coefficient; diffusion; electrodes; examination; 21361.

planar near-field measurements; precision parabolic reflector; radar cross-section measurements; antenna measurements; compact range; 21215.

planetary gears; bearing life; bearings; epicyclic system; gear train; planet bearings; *SP640*; 1982 October. 130-149.

planet bearings; planetary gears; bearing life; bearings; epicyclic system; gear train; *SP640*; 1982 October. 130-149.

planets, abundances; planets, atmospheres; planets, Jupiter; planets, Saturn; planets, spectra; ultraviolet, spectra; 21076.

planets, atmospheres; planets, Jupiter; planets, Saturn; planets, spectra; ultraviolet, spectra; planets, abundances; 21076.

planets, Jupiter; planets, Saturn; planets, spectra; ultraviolet, spectra; planets, abundances; planets, atmospheres; 21076.

planets, Saturn; planets, spectra; ultraviolet, spectra; planets, abundances; planets, atmospheres; planets, Jupiter; 21076.

planets, spectra; ultraviolet, spectra; planets, abundances; planets, atmospheres; planets, Jupiter; planets, Saturn; 21076.

plantinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; 20930.

plasma; rare-earth; absolute; calibration; continuum; irradiance; 21016.

plasma; Stark; strong collisions; line broadening; model microfield; 20846.

plasma; zinc; dietary enrichment; isotopes; mass spectrometry; neutron activation; 21374.

plasma broadening; plasma theory; relaxation theory; Stark broadening; Balmer lines; ion dynamics; Lyman series; 21368.

plasma coatings; thermal deposition systems; thermospray process; wear; aluminum non-skid coating; corrosion control; erosion; flame spray process; *SP640*; 1982 October. 194-196.

plasma diagnostics; ultraviolet detector; ultraviolet spectrograph; 21046.

plasma production and heating by laser beam; pulsed-dye laser application; resonance ionization spectroscopy; trace analysis of solids; two-photon absorption spectroscopy; laser ablation; laser-produced vaporization; laser-solid interaction; 20922.

plasma theory; relaxation theory; Stark broadening; Balmer lines; ion dynamics; Lyman series; plasma broadening; 21368.

plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles; directory; ferrous metals; glass; nonferrous metals; paper; *NBS-GCR-82-366*.

plastic-bonded; soils; telephone cables; underground; alloys; corrosion; metallurgically-bonded; metals; *NBSIR 82-2509*.

plastic containment materials; solar energy systems; standards; durability; *NBSIR 82-2533*.

plastic deformation; sorbate concentration; sorption; weight gain; concentration coefficient of diffusivity; density; diffusion coefficient; drawing stress; low density polyethylene; 20876.

plastic deformation; x-ray topography; copper single crystal; image contrast; indentation hardening; 21353.

plastic encapsulation; surface conductivity; integrated circuits; moisture reliability; *SP400-72*; 1982 April. 247-257.

plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; relative humidity effects; temperature effects; dosimetry; dyes; gamma radiation; 20975.

plasticity; strength; stress; toughness; collapse; cracks; defects; failure; fracture mechanics; girth welds; pipeline; 21169.

plastic necking instability; progressive crack growth; crack initiation; crack opening displacement; ductile fracture; leak vs. break; part-through crack; pipeline fracture; *SP621*; 1982 October. 153-164.

plastic plate; quinoline dye; solar energy; fading; measurement of lamp output; 20798.

plastics; smoke chamber; tables; ASTM E162; fire tests; flame spread; *NBSIR 81-2400*.

plastics; ventilation; fires; fire size; fuels; heat of combustion; heat release rate; *NBS-GCR-82-395*.

plating; aluminum; anodizing; electrodeposition; nickel adhesion; 21267.

platinum resistance thermometry; fixed points; International Practical Temperature Scale of 1968; 20932.

platinum surface; catalysis; chemiluminescence; CO; oxidation; 20821.

PLEED; spin dependent electron scattering; temperature phases; hydrogen chemisorption; 20865.

PL/I; specifications; validation; assertions; data abstractions;



- implementation; 20943.
- plumbing; water conservation; water fixtures; water heating facilities; flow reduction; *SP624*; 1982 June. 281-288.
- plumbing codes; plumbing fixtures; wastewater flows; water conservation; *SP624*; 1982 June. 379-397.
- plumbing drainage system; plumbing fixtures; transport mechanisms; transport phenomena; wall friction; building pipe drains; low water usage devices; pitch of the pipe; *SP624*; 1982 June. 293-326.
- plumbing fixtures; transport mechanisms; transport phenomena; wall friction; building pipe drains; low water usage devices; pitch of the pipe; plumbing drainage system; *SP624*; 1982 June. 293-326.
- plumbing fixtures; wastewater flows; water conservation; plumbing codes; *SP624*; 1982 June. 379-397.
- plumbing fixtures; water consumption; water-saving plumbing; control water flow; flow control devices; multi-housing properties; *SP624*; 1982 June. 47-51.
- plumbing products; appliances; fittings; fixtures; low flows; *SP624*; 1982 June. 289-292.
- plume; room fire; entrainment; flame angle; openings; 20810.
- plume fires; ceiling entrainment; fire flame length; 21094.
- plutonium dioxide; water determination; automatic titration; Karl Fischer reagent titration; moisture; nuclear safeguards; *NBSIR 82-2496*.
- plutonium isotopic abundances; radioactive decay; alpha-particle-emission rates; liquid-scintillation counting; plutonium-239 (half life); 21246.
- plutonium-239 (half life); plutonium isotopic abundances; radioactive decay; alpha-particle-emission rates; liquid-scintillation counting; 21246.
- pneumatic control system; velocity algorithm; building controls; digital-to-pneumatic conversion; direct digital control; energy controls; HVAC system; microprocessor control; 20995.
- pn junction temperature sensor; surface conductivity sensor; time response of moisture sensors; aluminum oxide moisture sensor; moisture sensors; *SP400-72*; 1982 April. 79-89.
- Pockels effect; polarization; accuracy; calibration; electro-optical measurements; frequency response; interferometric measurements; Kerr effect; *SP628*; 1982 June. 1-19.
- point-monodirectional beams; superposition; treatment planning; dosimetry; electrons; Monte Carlo; *NBSIR 82-2451*.
- Poisson equation; elliptic partial differential equations; finite difference methods; high order accuracy; 20779.
- Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; low-temperature; magnetic transition; physical properties; 21198.
- Poisson statistical process; statistical methods; analysis; asbestos fibers; chrysotile filter; filter homogeneity; *SP619*; 1982 March. 169-182.
- polarimetry; standards; calibration; 21127.
- polarizabilities; Van der Waals; damped dispersion; energy curve; 20788.
- polarization; accuracy; calibration; electro-optical measurements; frequency response; interferometric measurements; Kerr effect; Pockels effect; *SP628*; 1982 June. 1-19.
- polarization; standard antennas; VHF-UHF frequency range; wavelength-size scalar horns; antenna directivity pattern; antenna measurements; calculated radiation parameters; 21222.
- polarization;  $Zn^{+}$ ; crossed beams; cross sections; electron impact excitation; lifetime; 21072.
- polarization distribution; poling study; polyvinyl fluoride; pyroelectric; ferroelectric; piezoelectric; 21245.
- polarization distribution; thermal pulse experiment; charge distribution; computer analysis; data reduction; Fourier analysis; piezoelectric polymers; 21155.
- polarization ratio; radiation pressure; resonances; light scattering; liquid droplets; microspheres; Mie theory; optical levitation; particle sizing; 21054.
- polarized bremsstrahlung differential cross section; polarized photon beams; tagged photon method; Bethe-Heitler cross section; bremsstrahlung monochromator; photonuclear research; *NBSIR 82-2454*.
- polarized light microscopy; asbestos; bulk standards; construction materials; health risk; *SP619*; 1982 March. 34-43.
- polarized low energy; spin-orbit splitting; surface potential barrier tungsten (100); surface resonance; electron diffraction; 20976.
- polarized photon beams; tagged photon method; Bethe-Heitler cross section; bremsstrahlung monochromator; photonuclear research; polarized bremsstrahlung differential cross section; *NBSIR 82-2454*.
- polar molecules; electron-molecule collisions; MEAN approximation; 20952.
- polaron; polyacetylene; soliton; doping; impurity states; midgap absorption; nonhydrogenic states; 21104.
- polar solvents; radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; gamma radiation; liquid dye solution; 20902.
- police body armor; protective undergarments; armor; ballistic protection; ballistic threat; commercial body armor; performance standards; 20906.
- poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; 21392.
- poling; pyroelectricity; tetrafluoroethylene; vinylidene fluoride; charge transport; copolymer; electrical properties; piezoelectricity; 20840.
- poling study; polyvinyl fluoride; pyroelectric; ferroelectric; piezoelectric; polarization distribution; 21245.
- pollution control; reclaiming; re-refining; used oil; waste oil; lubricants; oil recycling; petroleum; 21383.
- polyacetylene; soliton; doping; impurity states; midgap absorption; nonhydrogenic states; polaron; 21104.
- polyacetylene; transport; conductivity; electrical; impedance; 20853.
- polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid); enthalpy; entropy; glass transition; heat capacity; linear macromolecule; *JPCRD 11(4)*: 1065-1089; 1982.
- polyacrylonitrile; polymethacrylamide; polymethacrylate; poly(methacrylic acid); enthalpy; entropy; glass transition; heat capacity; linear macromolecule; polyacrylate; *JPCRD 11(4)*: 1065-1089; 1982.
- polycyclic aromatic hydrocarbons; recirculation; soot formation; diffusion flames; flame stabilization; laser-induced fluorescence; 21343.
- polycyclic aromatic hydrocarbons; wall-coated open-tubular columns; gas-liquid chromatography; liquid crystals; 20965.
- polydimethylsiloxanes; breakdown; electrical insulation; high voltage; liquids; partial discharge; 21130.
- polyester; polyurethane; acid; carbodiimide; degradation; hydrolysis; kinetics; 20972.
- polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; textiles; upholstered furniture; cigarettes; fabrics; flammability; ignition; 21128.
- polyethylene; polyethylene fold planes; polymer; polymer crystallization; SANS; semicrystalline polymer; adjacent reentry; fold plane roughening; melt crystallization; 21160.
- polyethylene; polymer; polymer between two plates; rotational isomeric state model; switchboard model; gambler's ruin problem; Monte Carlo; 21138.
- polyethylene; polymer fiber; polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; 21175.
- polyethylene; polyolefins; poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; *NBSIR 81-2314*.
- polyethylene; polypropylene; radiotracer; antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; oligomers; *NBSIR 82-2472*.
- polyethylene; reflectometry; rf characteristics; transmission; treeing; aging; dielectric; distribution; electrical failure; 21140.
- polyethylene; régime I; régime II; reptation; crystallization; fraction; friction coefficient; growth rate; 21158.
- polyethylene; stress-crack resistance; stress-relaxation; ultra high molecular weight; creep; fatigue; morphology; *NBSIR 82-2493*.
- polyethylene film; thermistor; water calorimeter; absorbed dose; adiabatic; calorimeter; *U.S. Patent 4,312,224*.
- polyethylene fold planes; polymer; polymer crystallization; SANS; semicrystalline polymer; adjacent reentry; fold plane roughening; melt crystallization; polyethylene; 21160.
- polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; teflon; crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; melt index; melting point; 20900.
- polymer; polymer between two plates; rotational isomeric state model; switchboard model; gambler's ruin problem; Monte Carlo; polyethylene; 21138.
- polymer; polymer crystallization; SANS; semicrystalline polymer;



adjacent reentry; fold plane roughening; melt crystallization; polyethylene; polyethylene fold planes; 21160.

polymer; polymer interfaces; adjacent reentry; density at interface; distribution of polymer loops; interfacial thickness; 21065.

polymer; semicrystalline polymer; small angle neutron scattering; switchboard model of polymer surface; adjacent reentry model of crystal and amorphous phase in polymer; 21161.

polymer; semicrystalline polymer; tie molecules; amorphous phase; crystal-amorphous interface; fold surface; loops; 21159.

polymer; toxicity; autopsy; biological; carboxyhemoglobin; fatalities; hydrogen cyanide; 20811.

polymer adsorption; probability of first return; restricted random walk; absorbing points; lattice random walk; mean occupation time; 20826.

polymer between two plates; rotational isomeric state model; switchboard model; gambler's ruin problem; Monte Carlo; polyethylene; polymer; 21138.

polymer coating; rust prevention; vehicular rust; battery-acid corrosion; metal coating; SP640; 1982 October. 275-289.

polymer crystallization; SANS; semicrystalline polymer; adjacent reentry; fold plane roughening; melt crystallization; polyethylene; polyethylene fold planes; polymer; 21160.

polymer crystals; block copolymers; chain folding in polymers; copolymer; phase transition in polymers; 21066.

polymer fiber; polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; 21175.

polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosanine; leucocyanide dyes; nylon; 20905.

polymer glasses; equilibrium theory; glass formation; glass transition; 21067.

polymeric implants; prolyl hydroxylase; enzymatic assay; gas chromatography/mass spectrometry; leachables; mammary prosthesis; NBSIR 81-2436.

polymeric materials; solubility; diffusion; hydrophobic; moisture permeation; SP400-72; 1982 April. 239-245.

polymer interfaces; adjacent reentry; density at interface; distribution of polymer loops; interfacial thickness; polymer; 21065.

polymerization; water sorption; absorption; composite resins; expansion; hardening shrinkage; hygroscopic expansion; 21052.

polymer physics; simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; 21175.

polymers; polystyrene; pyrolysis; radiation flux; combustion; degradation; NBS-GCR-82-403.

polymers; resistance; resistivity; review; alloys; conductivity; electrical property; metals; TN1053.

polymers; room fires; thermal degradation; ceilings; charring; compartment fires; corridors; flame spread; NBS-GCR-82-377.

polymers; size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; NMR; organometallic polymers; NBSIR 81-2424.

polymethacrylamide; polymethacrylate; poly(methacrylic acid); enthalpy; entropy; glass transition; heat capacity; linear macromolecule; polyacrylate; polyacrylonitrile; JPCRD 11(4): 1065-1089; 1982.

polymethacrylate; poly(methacrylic acid); enthalpy; entropy; glass transition; heat capacity; linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; JPCRD 11(4): 1065-1089; 1982.

polymethacrylate; radiation; surface temperature; wood; absorption; CO<sub>2</sub> laser; decomposition; ignition; 20792.

poly(methacrylic acid); enthalpy; entropy; glass transition; heat capacity; linear macromolecule; polyacrylate; polyacrylonitrile; polymethacrylamide; polymethacrylate; JPCRD 11(4): 1065-1089; 1982.

polymethylmethacrylate; radiation; red oak; surface temperature; absorption; ignition; 21305.

polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; relative humidity effects; temperature effects; dosimetry; dyes; gamma radiation; plastic films; 20975.

polymethylmethacrylate; radiative ignition; red oak; surface temperature; ignition; ignition surface temperature; 21306.

polymorphism; p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; experimental melting curves; high pressure; high temperature; JPCRD 11(4): 1005-1064; 1982.

polynuclear aromatic hydrocarbons; shale oil analysis; solvent refined coal; determination of benzo[a]pyrene; multidimensional chromatographic analysis; on-line sequential liquid chromatographic analysis; 20981.

polyolefins; poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; polyethylene; NBSIR 81-2314.

polypropylene; radiotracer; antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; oligomers; polyethylene; NBSIR 82-2472.

polysilicon films; silicon dioxide films; silicon nitride films; standard reference materials; thin films; ellipsometry; 21107.

polystyrene; Aroclor; dynamic intrinsic viscosity; internal viscosity; necklace model; 21059.

polystyrene; atactic; crystal; crystallinity; density; enthalpy; fusion; glass transition; heat capacity; isotactic; linear macromolecule; melt; JPCRD 11(2): 313-325; 1982.

polystyrene; pyrolysis; radiation flux; combustion; degradation; polymers; NBS-GCR-82-403.

polytetrafluoroethylene; tetrafluoroethylene; x-ray diffraction; copolymers; crystal; hexafluoropropylene; 21164.

polytrifluoroethylene; pyroelectricity; thermal expansion; chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; 21395.

polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; 21392.

polyurethane; acid; carbodiimide; degradation; hydrolysis; kinetics; polyester; 20972.

polyurethane foam; self-extinguishment; smoldering; test development; textiles; upholstered furniture; cigarettes; fabrics; flammability; ignition; polyester batting; 21128.

polyvalent electrolytes; thermodynamics properties; activity coefficient; correlation; critical evaluation; electrolyte theories; models; osmotic coefficient; 20935.

polyvinyl butyral; radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosanine; leucocyanide dyes; nylon; polymer films; 20905.

poly(vinyl chloride); diffusion; extraction; food packaging; heat stabilizers; migration; octyltins; 21325.

poly(vinyl chloride); PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; NBSIR 81-2314.

polyvinyl fluoride; pyroelectric; ferroelectric; piezoelectric; polarization distribution; poling study; 21245.

pooling of variance; weighted average; weighted least squares regression; ANOVA (within-between); components of variance; consensus values; design of experiments; J. Res. 87(5): 377-385; 1982 September-October.

poor shaft and housing fits; smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; SP640; 1982 October. 257-274.

porcelain enamel restoration; restoration coatings; accelerated bathtub exposure cycle; performance criteria for restoration coatings; NBSIR 82-2553.

pore water pressure; sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; BSS138.

portability; program inventory; RFP; statement of work; acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; SP500-90.

portable; rapid; wear-metal analysis; colorimetric iron kit; iron; jet engine oil; SP640; 1982 October. 455-465.

portable system; truck-mounted; CCVT; compact; field calibration; high accuracy; modular capacitive divider; 21287.

Portland aerosol characterization study; radiocarbon; residential wood burning; urban particulates; vegetative burning; air pollution;



biogenic/fossil carbon impact; field and slash burning; 20964.  
positional set notation; set-theoretic; database management systems; data models; DBMS simulation; 21270.  
position-sensitive detectors; precision of data; x rays; diffractometry; macromolecular crystallography; neutrons; 20982.  
position-sensitive proportional counter; associated particles; neutron imaging; neutron sources; pin-hole camera; 21312.  
positrons; radiation yield; radiative stopping power; range; collision stopping power; electrons; NBSIR 82-2550.  
post-marketing surveillance; regulatory experiments; drug development; drug regulation; innovation; NBS-GCR-ETIP 82-99.  
post-tensioning; structural analysis; bridge; collapse; concrete; construction; failure investigation; falsework; field load tests; formwork; NBSIR 82-2593.  
potable water; pressure reduction; residential buildings; sprinkler systems; water; corrosion; friction reduction; pipes; NBS-GCR-82-399.  
potable water conservation; wastewater treatment; wastewater treatment utilities; water supply utilities; household water conservation program; SP624; 1982 June. 247-258.  
potable water reduction; water conservation; municipal water systems; SP624.  
potassium carbonate; solubility; solutions; thermodynamics; activity coefficient; electrolytes; excess Gibbs energy; isopiestic; osmotic coefficient; 21233.  
potassium hydroxide; solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; NBSIR 81-2356.  
potential functions; spectral moments; translational spectrum; wave mechanical lineshapes; argon; binary mixtures; collision-induced absorption; 20929.  
potential functions; spectroscopy; absorption; high temperature; hydrogen isocyanide; infrared; molecular structure; 20782.  
potential profiling; spreading resistance; contacts; gallium arsenide; NBSIR 81-2403.  
potentials; scaling; Fermion masses; internal spaces; mixing angles; neutrino oscillations; 21168.  
potentiostat; anodic oxidation; dissolution of passive films; ellipsometry; iron; passive films; 20882.  
Potomac River and Trails Council; Project Water Watch; wastewater treatment systems; water conservation; SP624; 1982 June. 69-80.  
powder; pyrolysis; retardant; smolder; thermogram; cellulose; combustion; flame; inhibition; inorganic; 20799.  
powder diffraction file; x ray; crystal data; diffraction; Hanawalt search procedure; 21271.  
powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence; austenite in ferrite; SP260-78.  
powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence; austenite in ferrite; SP260-76.  
powder method; Rietveld method; solid solution; tantalum oxide; lithium tantalate; neutron diffraction; 21157.  
powder patterns; reference intensities; standard; x-ray diffraction; crystal structure; densities; lattice constants; Monogr. 25, Section 19.  
powder refinement; significant differences; statistical analysis; comparison of models; linear regression; neutron diffraction; 21401.  
power-device grade silicon; transient capacitance techniques; deep-level measurements; deep-level transient spectroscopy; defect characterization; lifetime; NBSIR 82-2552.  
power-law crack growth; ceramic fracture test; crack growth of ceramics; four-point bend test; fracture test; initial value problem; load-displacement characteristics; NBSIR 82-2504.  
power law spectra; time-domain stability; white noise; flicker noise; frequency stability; oscillator noise modeling; 21284.  
power law spectrum; time-domain stability; white noise; flicker noise; frequency-domain stability; frequency stability; oscillator noise modeling; 21209.  
power measurements; radiation pattern; TEM cell; total radiated power; dipole moments; electrically small; interference source; leakage; phase measurements; TN1059.  
powerplant/component/support shop functions; aircraft maintenance functions; maintenance information systems functions; management and financial functions; master planning; material and logistics functions; personnel/component/support shop functions; SP640; 1982 October. 27-44.  
power semiconductors; reverse-bias second breakdown; testing; voltage; clamping; diode recovery; high power measurements; high voltage; overshoot; 20849.  
power transistors; radiation effects; semiconductor devices; VDMOS; drain-source resistance; electron devices; gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; 21000.  
Pr; Sm; Tb; wavelength; Ce; energy levels; Eu; Gd; Ho; Nd; 20877.  
practice; samplers; soil tests; standard penetration tests; drills; in situ test; penetration tests; 20867.  
precipitation; rain; reference materials; trace elements; acidity; acid rain; chemical analysis; conductance; pH; NBSIR 82-2581.  
precision; reference materials; standards; trace analysis; accuracy; high purity materials; instrumental neutron activation analysis; 20997.  
precision instrument bearings; antistat-bearing steel interaction; antistatic agents; antistat-lubricant interaction; bearing packaging materials; bearing steel wettability; lubricant displacement; SP640; 1982 October. 290-294.  
precision laser spectroscopy; FM spectroscopy; laser frequency control; optical heterodyne spectroscopy; 21170.  
precision measurement; x-ray interferometry; x rays; crystal diffraction; gamma-ray standards; 21086.  
precision measurements; quantum limits; quantum nondemolition; quasi-coherent states; gravitational wave detector; harmonic oscillator; 20980.  
precision of data; x rays; diffractometry; macromolecular crystallography; neutrons; position-sensitive detectors; 20982.  
precision parabolic reflector; radar cross-section measurements; antenna measurements; compact range; planar near-field measurements; 21215.  
precision shunts; pulsed currents; Zero Gradient Synchrotron; current transformers; SP628; 1982 June. 204-216.  
precision x-ray energies; experimental/theoretical comparisons; 21109.  
precondensation; propane; sorption; speed of sound; velocity of sound; acoustical measurements; acoustic resonator; adsorption; nitrogen; physical acoustics; 21230.  
predissociation; transition probability assignment; Ca<sub>2</sub>; charge density; electronic spectra; 21310.  
preference parameters; requirements; cost parameters; database management; data management evaluation; DBMS; decision model; NBS-GCR-82-373.  
preference parameters; requirements; cost parameters; DBMS; database management; data management; data management evaluation; decision model; NBS-GCR-82-375.  
preference parameters; requirements; cost parameters; DBMS; database management; data management; data management evaluation; decision model; NBS-GCR-82-374.  
preparation techniques; aqueous standard fiber dispersions; asbestos analysis variability; fiber identification criteria; interlaboratory calibration; SP619; 1982 March. 91-107.  
pressure; pressure scale; standards; calibration; measurement; metrology; 20988.  
pressure; pulsed oscillator; pulsed sensor; temperature; tunnel diode; tunnel diode oscillator; LC oscillator; oscillator sensor; 21064.  
pressure; transducer; 21020.  
pressure difference; pressure transducer; standards; calibration; differential manometer; piston gage; TN1052.  
pressure reduction; residential buildings; sprinkler systems; water; corrosion; friction reduction; pipes; potable water; NBS-GCR-82-399.  
pressure scale; standards; calibration; measurement; metrology; pressure; 20988.  
pressure temperature; thermal conductivity; transient; hot wire; oxygen; J. Res. 87(4): 279-310; 1982 July-August.  
pressure transducer; standards; calibration; differential manometer; piston gage; pressure difference; TN1052.  
pressure vessel; pump; reliability; risk analysis; valve; database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; 21176.  
pressurization; smoke control; stairwells; building fires; egress; elevators; handicapped; 21226.  
pressurization; smoke control; stairwells; building fires; egress; elevators (lifts); evacuation; handicapped; NBSIR 82-2507.  
pressurized tank car; stress-rupture; fracture control; hazardous materials; impact transition; SP621; 1982 October. 18-32.  
prevention; diagnostic controls; hydro-dynamic condition; lubrication systems; maintenance program; SP640; 1982 October. 170-186.



preventive maintenance; composite inspection; corrosion detection; cost savings; NDE; neutron radiography; *SP640*; 1982 October. 417-453.

preventive maintenance; rental apartment complexes; waste flow; water conservation; watersaving devices; controlled installation; leak detection; *SP624*; 1982 June. 169-171.

preventive maintenance; wear; corrosion; failure prevention; human performance; material and material processing; mechanical and structural failure; operational environment; *SP640*; 1982 October. 2-16.

preventive maintenance plan; programmed inspections; cost effectiveness; maintenance effectiveness; *SP640*; 1982 October. 86-112.

pricing; billing systems; chargeback systems; charging systems; cost accounting; costing; DP accounting; *SP500-95*; 1982 October. 425.

primary frequency standards; SI second; automatic time comparison; deep space network; differential time transfer; frequency transfer; Global Positioning System; international time comparison; *21204*.

primary standard; cavity phase shift; cesium clock; frequency standard evaluation; frequency standard uncertainties; NBS-6; *21251*.

prison cell fire; smoke; fire growth; fuel load; heat release rate; *NBSIR 82-2469*.

probability of first return; restricted random walk; absorbing points; lattice random walk; mean occupation time; polymer adsorption; *20826*.

probe antenna; radiation resistance; rectangular coaxial transmission line; TEM cell; variational method; Green's function; input impedance; *TN1054*.

probe spacing; sheet resistance; spreading resistance; multilayer Laplace equation; *20984*.

problem solving; process planning; AMRF; artificial intelligence; automated manufacturing; expert systems; knowledge-based systems; knowledge engineering; knowledge representation; *NBSIR 81-2466*.

procedure; chlorinated benzenes; chlorinated dioxins; chlorinated phenols; estimation; heats of formation; *21346*.

procedures; software; compatibility; guidelines; *SP500-94*; 1982 October. 80-83.

proceedings; serials; standards; transactions; annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; *NBSIR 82-2575*.

process control; process validation wafer; silicon on sapphire; test chip; test pattern; test structure; yield; integrated circuits; microelectronics; *NBSIR 82-2514*.

process control; process validation wafer; test pattern; test structure; wafer map; integrated circuits; microelectronics; *20838*.

process control; pulse-echo technique; signal processing; solidification; ultrasonics; interface; measurement; melting; metals; *21362*.

process control; sheet resistance; test structure; cross-bridge structure; linewidth; microelectronic test structure; *NBSIR 82-2548*.

processed used oil; recycled oil; burner fuel; fuel oil; petroleum; petroleum testing; *21394*.

process planning; AMRF; artificial intelligence; automated manufacturing; expert systems; knowledge-based systems; knowledge engineering; knowledge representation; problem solving; *NBSIR 81-2466*.

process-related radiation damage; radiation dose; device fabrication; electron-beam metallization; electron devices; ionizing radiation; microelectronics; *21184*.

process validation wafer; silicon on sapphire; test chip; test pattern; test structure; yield; integrated circuits; microelectronics; process control; *NBSIR 82-2514*.

process validation wafer; statistical analysis; two-dimensional arrays; wafer map; computer program; correlation coefficient; outlier; *NBSIR 82-2492*.

process validation wafer; test pattern; test structure; wafer map; integrated circuits; microelectronics; process control; *20838*.

process waters; shale oil; speciation; arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; *21125*.

procurement; purchasing; recovered/recycled materials; resource recovery; bid-modifier; disposal costs; PAR factor; *NBS-GCR-82-400*.

procurement; purchasing; recycling; resource recovery; rubber; textiles; directory; ferrous metals; glass; nonferrous metals; paper; plastic; *NBS-GCR-82-366*.

procurement; regulation; research and development; technology policy; administrative experiments; economic assistance; innovation; *NBS-GCR-ETIP 82-100*.

procurement; relational; standards; database management; DBMS; functional specification; mandatory requirements; optional requirements; *NBS-GCR-82-372*.

product assurance; software maintenance; testing; traceability; visibility; *SP500-94*; 1982 October. 23-29.

product certification; system operation; accreditation; certification; functions; laboratory accreditation; *SP632*; 1982 March. 24-27.

product certification program; testing laboratory; laboratory accreditation; *SP632*; 1982 March. 70-72.

productivity; computer-based applications; data processing; Information Resource Management; *SP500-95*; 1982 October. 19-24.

productivity; science; software edge; fundamental research; Government-industry relationships; industrial technology; NBS 80th Anniversary; *SP627*.

productivity; vibration; balancing; diagnostics; faults; jet engines; monitoring; overhaul; *SP640*; 1982 October. 115-129.

productivity analysis; computerized analysis; electric utility rate regulation; Experimental Technology Incentives Program; innovation; *NBSIR 80-2046*.

product state distributions; review infrared multiphoton dissociation; CF<sub>3</sub>HCl; CF<sub>3</sub>CFCl; infrared excitation; multiphoton dissociation; *21334*.

profile refinement; rare earths; crystal fields; ferromagnetism; manganese compounds; neutron diffraction; *20944*.

program analysis; program instrumentation; software tools; coverage analysis; dynamic analysis; performance monitoring; *SP500-95*; 1982 October. 195-202.

program complexity; software testing; structured testing; measures; metric; *SP500-99*.

program design; program documentation; program document standardization; program testing; software engineering; automated tools; *SP500-94*; 1982 October. 95-109.

program documentation; program document standardization; program testing; software engineering; automated tools; program design; *SP500-94*; 1982 October. 95-109.

program documentation; software documentation; standards; documentation; FIPS; guidelines; *SP500-94*.

program document standardization; program testing; software engineering; automated tools; program design; program document; *SP500-94*; 1982 October. 95-109.

program instrumentation; software tools; coverage analysis; dynamic analysis; performance monitoring; program analysis; *SP500-95*; 1982 October. 195-202.

program inventory; RFP; statement of work; acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; portability; *SP500-90*.

programmed inspections; cost effectiveness; maintenance effectiveness; preventive maintenance plan; *SP640*; 1982 October. 86-112.

programming aids; software automation; software development; software engineering; software testing; software tools; *SP500-88*.

programming aids; software development; software engineering; software tools; static analysis; compilers; dynamic analysis; *NBSIR 81-2423*.

programming aids; software development; software engineering; software tools; static analysis; compilers; dynamic analysis; *NBS-GCR-82-376*.

programming language; self documenting; English-like; *SP500-94*; 1982 October. 84-94.

program testing; software engineering; automated tools; program design; program documentation; program document standardization; *SP500-94*; 1982 October. 95-109.

progressive crack growth; crack initiation; crack opening displacement; ductile fracture; leak vs. break; part-through crack; pipeline fracture; plastic necking instability; *SP621*; 1982 October. 153-164.

project management standards; documentation standards; information processing system standards; *SP500-94*; 1982 October. 160-164.

project summaries; technical bases; building research; building technology; codes; criteria; measurement methods; performance criteria; *SP446-6*.

Project Water Watch; wastewater treatment systems; water conservation; Potomac River and Trails Council; *SP624*; 1982 June. 69-80.

prolyl hydroxylase; enzymatic assay; gas chromatography/mass



spectrometry; leachables; mammary prosthesis; polymeric implants; *NBSIR 81-2436*.

proof testing; reliability; silicon nitride; structural ceramics; deformation maps; high temperatures; *NBSIR 81-2445*.

propane; relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients; equation of state; ethylene; ideal gas heat capacity; physical acoustics; *21208*.

propane; sorption; speed of sound; velocity of sound; acoustical measurements; acoustic resonator; adsorption; nitrogen; physical acoustics; precondensation; *21230*.

propane; specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; *Monogr. 170*.

propane; thermal conductivity; transient hot wire; liquid; *20831*.

propane; viscosity; corresponding states; Enskog model; equation of state; hard spheres; *21225*.

properties; solid; crystal structure; hydrogen; phase diagram; *20979*.

property; sensor; solar test building; cross-section; description; passive; physical; *NBS-GCR-82-398*.

propionitrile; radio astronomy; rotational spectrum; ethanol; intensities; interstellar molecules; microwave spectra; molecular constants; *JPCRD 11(2): 251-312; 1982*.

propylene; proton affinity; alkyl halide; breakdown curve; metastable transition; photoelectron photoion coincidence; *21097*.

protective coatings; test apparatus; test method; adhesion; measurement; *NBSIR 82-2535*.

protective performance; substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; *TN1150*.

protective undergarments; armor; ballistic protection; ballistic threat; commercial body armor; performance standards; police body armor; *20906*.

protein separation; chemical analysis; electrochemistry; membranes; olfaction; *NBS-GCR-82-378*.

protein structure; refinement; ribonuclease; amide protection; flexibility; hydrogen exchange; *21137*.

protein structure; ribonuclease; x-ray diffraction; active site; charge relay; enzymes; *20893*.

protein structure; ribonuclease-S; semi-synthetic proteins; x-ray methods; active site; hydrogen bonds; *20914*.

protocols; relaxation time; sensitivity; slotted aloha; throughput; transition matrix; carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; *SP500-95; 1982 October. 365-373*.

protocol specification methods; automatic implementation techniques; communication protocols; computer network protocols; formal description techniques; *21034*.

protocol standards; standards; distributed computing; high level protocols; networking performance; network protocols; *21386*.

protocol standards; telecommunications; computer networks; distributed data; Government and industry; *21265*.

proton affinities; radicals; aromatic hydrocarbons; bond energies; ion-molecule reactions; *20950*.

proton affinity; alkyl halide; breakdown curve; metastable transition; photoelectron photoion coincidence; propylene; *21097*.

proton current; pulsed generators; pulsed power; voltage determinations; deuteron current; dielectric; neutron; *SP628; 1982 June. 104-117*.

PSD; synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; ESD; oxygen; photon stimulated desorption; *20832*.

PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; water; hydrogen; oxygen; photon stimulated desorption; *21005*.

PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; hydrogen; methanol; methoxy; oxygen; photon stimulated desorption; *21296*.

psychiatry; psychopathic personality; psychopathology; arson; behavior disorder; fire; firesetters; motives; *21335*.

psychological needs; view out; window; window management; control; daylight; energy balance; natural ventilation; *21043*.

psychopathic personality; psychopathology; arson; behavior disorder; fire; firesetters; motives; psychiatry; *21335*.

psychopathology; arson; behavior disorder; fire; firesetters; motives; psychiatry; psychopathic personality; *21335*.

p, T phase diagrams; solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; experimental melting curves; high pressure; high temperature; polymorphism; *JPCRD 11(4): 1005-1064; 1982*.

public; analytical laboratories; clients; international trading; laboratory accreditation; *SP632; 1982 March. 46-51*.

publications; abstracts; building technology; Center for Building Technology; key words; *SP457-6*.

publications, NBS; abstracts, NBS publications; key words; *SP305. Supplement 13*.

public awareness; toilet dams; wastewater flow reduction; water conservation; faucet aerators; flow reduction; groundwater law; *SP624; 1982 June. 151-154*.

public education programs; urban water resource planning; water conservation; *SP624; 1982 June. 179-190*.

publishers; book prices; copyright law; inflation; interlibrary lending; journal prices; library photocopying; *21380*.

pullout test; stress contours; concrete; crack propagation; failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; large scale models; mathematical model; *NBSIR 82-2484*.

pulsars; stars, individual; x rays, binaries; *21009*.

pulse; standards; waveform generation; waveform measurements; waveform recorder; converters; electromagnetics; encoders; *SP634*.

pulse analysis; pulse waveform analysis; waveform analysis; waveform recording; automated oscilloscope; computer aided measurement; laboratory automation; *SP634; 1982 June. 55-67*.

pulse circuits; computer simulation; mathematical modeling; *SP628; 1982 June. 133-149*.

pulse current; current measurement; current viewing resistors; *SP628; 1982 June. 217-232*.

pulsed current measurements; Rogowski coils; current sensors; fluxmeters; *SP628; 1982 June. 175-193*.

pulsed currents; Zero Gradient Synchrotron; current transformers; precision shunts; *SP628; 1982 June. 204-216*.

pulsed-dye laser application; resonance ionization spectroscopy; trace analysis of solids; two-photon absorption spectroscopy; laser ablation; laser-produced vaporization; laser-solid interaction; plasma production and heating by laser beam; *20922*.

pulsed electric currents; Faraday effect; *SP628; 1982 June. 277-288*.

pulsed generators; pulsed power; voltage determinations; deuteron current; dielectric; neutron; proton current; *SP628; 1982 June. 104-117*.

pulsed oscillator; pulsed sensor; temperature; tunnel diode; tunnel diode oscillator; LC oscillator; oscillator sensor; pressure; *21064*.

pulsed power; voltage determinations; deuteron current; dielectric; neutron; proton current; pulsed generators; *SP628; 1982 June. 104-117*.

pulsed power generators; cable attenuation; Fast Fourier Transforms; high speed transient digitizers; *SP628; 1982 June. 381-391*.

pulsed sensor; temperature; tunnel diode; tunnel diode oscillator; LC oscillator; oscillator sensor; pressure; pulsed oscillator; *21064*.

pulse-echo technique; signal processing; solidification; ultrasonics; interface; measurement; melting; metals; process control; *21362*.

pulse emission; streak-camera; tunable; dye laser; mode-locked; picosecond; *21348*.

pulse energy; pulse peak power; 1.064  $\mu\text{m}$  laser pulse measurements; APD transfer standards; beamsplitter attenuator; impulse response measurements; low-level laser measurements; modulated cw measurement system; PIN transfer standards; *TN1058*.

pulse generators; Antares; calibration; inertial confinement fusion studies; *SP628; 1982 June. 320*.

pulse generators; Rogowski coils; current monitors; current probe; current pulses; *SP628; 1982 June. 289-299*.

pulse generators; voltage probes; calibrations; capacitance-current; dielectric; high voltage pulser; *SP628; 1982 June. 59-68*.

pulse heating; radiance temperature; tungsten; melting; normal spectral emittance; *21227*.

pulse measurements; time domain measurements; waveform measurements; waveform recorders; errors; *SP634; 1982 June. 1-5*.

pulse peak power; 1.064  $\mu\text{m}$  laser pulse measurements; APD transfer standards; beamsplitter attenuator; impulse response measurements; low-level laser measurements; modulated cw measurement system; PIN transfer standards; pulse energy; *TN1058*.

pulse pileup; accuracy; activation analysis; count rate effects; dead time; errors; *21249*.

pulse power; transients; voltage measurements; current measurement; electrical measurements; electromagnetic pulse; fusion; nuclear



effects simulation; particle beam technology; *SP628*.  
pulse power environment; instrumentation amplifiers; *SP628*; 1982 June. 365-377.  
pulse power system; signal transmission; system fault isolation; thyatrons; current measurements; *SP628*; 1982 June. 248-255.  
pulse radiolysis; radiation processing; radiochromic dyes; bleaching of dyes; dose rate; dosimetry; dyes; film dosimetry; gamma rays; humidity effects; leucocyanics; *20844*.  
pulse voltage monitor; voltage monitor; waterline voltage monitor; capacity divider; high voltage divider; *SP628*; 1982 June. 20-25.  
pulse waveform analysis; waveform analysis; waveform recording; automated oscilloscope; computer aided measurement; laboratory automation; pulse analysis; *SP634*; 1982 June. 55-67.  
pultrusions; standards; composite materials; damage; fatigue; guys; mechanical testing; nondestructive testing; *21195*.  
pump; reliability; risk analysis; valve; database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; *21176*.  
purchasing; recovered/recycled materials; resource recovery; bid-modifier; disposal costs; PAR factor; procurement; *NBS-GCR-82-400*.  
purchasing; recycling; resource recovery; rubber; textiles; directory; ferrous metals; glass; nonferrous metals; paper; plastic; procurement; *NBS-GCR-82-366*.  
purge/and trap sampling; tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; *20999*.  
purification; separation; chemical engineering; facilitated transport; liquid membrane; membrane; *21241*.  
purpose; facility design; future plans; implementation; objectives; *SP609*; 1982 February. 77-79.  
PVC; additives; diffusion; ethylene vinyl acetate copolymers; food additives; indirect additives; migration; octyltins; organotins; polyethylene; polyolefins; poly(vinyl chloride); *NBSIR 81-2314*.  
PVT; specific heats; speed of sound; thermodynamic properties; vapor pressure; enthalpy; equation of state; heavy water; Helmholtz function; *JPCRD 11(1)*: 1-14; 1982.  
PVT; volume; volumetric properties; apparent molal volume; aqueous sodium chloride solutions; compressibility; density; equation of state; expansivity; Pitzer's equations; *JPCRD 11(1)*: 15-81; 1982.  
pyridine derivatives; Raman spectroscopy; silver electrode; surface-enhanced Raman spectroscopy; adsorption; electrode processes; N-methylpyridinium iodide; *21262*.  
pyroelectric; ferroelectric; piezoelectric; polarization distribution; poling study; polyvinyl fluoride; *21245*.  
pyroelectricity; tetrafluoroethylene; vinylidene fluoride; charge transport; copolymer; electrical properties; piezoelectricity; poling; *20840*.  
pyroelectricity; thermal expansion; chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; *21395*.  
pyroelectricity; trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; *21392*.  
pyrolysis; radiation flux; combustion; degradation; polymers; polystyrene; *NBS-GCR-82-403*.  
pyrolysis; retardant; smolder; thermogram; cellulose; combustion; flame; inhibition; inorganic; powder; *20799*.  
pyrolysis; solid fuels; additives; computer models; flame spread; *NBS-GCR-82-396*.

## Q

quadrupole rf trap; atomic spectroscopy; ion trap; laser cooling; light pressure; Penning trap; *21011*.  
quality assurance; building materials; concrete; evaluation; inplace testing; inspection; nondestructive testing; *J. Res. 87(5)*: 407-438; 1982 September-October.  
quality assurance; radon; standards; calibration; measurement; *20834*.  
quality assurance; secondary standard laboratory; traceability; calibrations; ionizing radiation; measurements; national standards; *SP609*.  
quality assurance; standard reference material; traceability; calibration; ionizing radiation; measurement; national standards;

*SP609*; 1982 February. 45-58.  
quality assurance; standards; traceability; calibrations; instruments; ionizing radiation; measurements; measurement support system; *SP609*; 1982 February. 3-10.  
quality control; quality control tool; system verification; user information; users manual; *SP500-94*; 1982 October. 256-264.  
quality control; radiation measurement; radiation performance; radiation measurements; regulatory standards; accuracy; bioassay performance; occupational radiation protection standards; performance criteria; *SP609*; 1982 February. 149-169.  
quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; *SP609*; 1982 February. 171-178.  
quality control; radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; *20974*.  
quality control; reliability of semiconductor devices; semiconductor devices; analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; moisture generators; moisture sensors; *SP400-72*.  
quality control; thermal shock; Cerdip; glass sealed; integrated circuit; packages; *SP400-72*; 1982 April. 234-238.  
quality control; welded steel bridges; fracture control; nondestructive inspection; *SP621*; 1982 October. 130-142.  
quality control radiation processing; radiation crosslinking; teflon; crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; *20900*.  
quality control tool; system verification; user information; users manual; quality control; *SP500-94*; 1982 October. 256-264.  
quality degradation; water conservation; depletion of supply; myth of abundant water; *SP624*; 1982 June. 155-156.  
quantitative analysis; standards; water vapor; certification; mass spectrometry; Method 1018; *SP400-72*; 1982 April. 32-38.  
quantitative analysis; water vapor; calibration; certification; mass spectrometry; method 1018.2; *SP400-72*; 1982 April. 39-48.  
quantitative forecasting techniques; workload forecasting; life-cycle management; *SP500-95*; 1982 October. 435.  
quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence; austenite in ferrite; powder metallurgy; *SP260-76*.  
quantitative microscopy; retained austenite standard; standard reference material; x-ray fluorescence; austenite in ferrite; powder metallurgy; *SP260-78*.  
quantizing error; signal-to-noise ratio; time domain; transient recorder; analog-to-digital converter; digitizer; dynamic testing; effective number of bits; frequency domain; *SP634*; 1982 June. 7-21.  
quantum efficiency; quantum yield; silicon photodiode; spectral response; collection efficiency; *21396*.  
quantum limits; quantum nondemolition; quasi-coherent states; gravitational wave detector; harmonic oscillator; precision measurements; *20980*.  
quantum mechanics; uncertainty relations; vector potential; Bohm-Aharonov; electrical transformer; interference; *20794*.  
quantum nondemolition; quasi-coherent states; gravitational wave detector; harmonic oscillator; precision measurements; quantum limits; *20980*.  
quantum parameter; corresponding states; critical point universality; liquefaction of helium; mechanical equivalence; mixtures; molecular potential; *20899*.  
quantum yield; rate coefficient; air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photo-absorption cross section; photochemistry; *JPCRD 11(2)*: 327-496; 1982.  
quantum yield; silicon photodiode; spectral response; collection efficiency; quantum efficiency; *21396*.  
quantum yield; transfer standard; absolute calibration; absolute quantum yield; actinometry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; *21045*.  
quantum yields; radiation chemistry; vacuum ultraviolet; charge recombination; cyclopentane; photofragmentation; photoionization; *21243*.  
quartetting; supermultiplets; atomic masses; binding energies; mass formula; nuclear shell effects; *20939*.  
quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid



calorimetry; platinum solution calorimetry; 20930.  
 quartz crystal resonators; quartz resonator thermometry; hysteresis; 20934.  
 quartz resonator thermometry; hysteresis; quartz crystal resonators; 20934.  
 quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; 20930.  
 quasi-coherent states; gravitational wave detector; harmonic oscillator; precision measurements; quantum limits; quantum nondemolition; 20980.  
 quasi-free; charge magnetization; Coulomb sum rule; electron scattering; Fermi gas model; nuclear response function; nuclei; nucleons; 21400.  
 quenching; resonance; sodium; transport; backscattering; experiment; forward scattering; 20953.  
 query language; relation; relational model; Relational Task Group; American National Standards Institute; computer standards; DBMS; database management; database standards; Data Base System Study Group; NBS-GCR-82-379.  
 queue; simulation; waiting time; capacity; dam; lock; NBSIR 81-2411.  
 queue drops; VM monitor; VM performance analysis; CPU utilization; SP500-95; 1982 October. 321-329.  
 queueing model; queueing networks; approximate queueing model; computer architecture; performance modeling; 20969.  
 queueing models; queueing networks; shared device; computer architecture; performance evaluation; performance modeling; 20802.  
 queueing models; resource measurement facilities; simulation; supercomputers; workload characterization; benchmarking; capacity planning; chargeback systems; computer performance management systems; SP500-95.  
 queueing network models; efficient evaluation algorithms; modelling; SP500-95; 1982 October. 437.  
 queueing network models; software packages; network model analysis; SP500-95; 1982 October. 183-187.  
 queueing networks; approximate queueing model; computer architecture; performance modeling; queueing model; 20969.  
 queueing networks; shared device; computer architecture; performance evaluation; performance modeling; queueing models; 20802.  
 queueing theory; UNIX; validation; performance prediction; SP500-95; 1982 October. 205-211.  
 queueing models; simulation; software package; systems performance; approximation techniques; SP500-95; 1982 October. 139-154.  
 quinoline dye; solar energy; fading; measurement of lamp output; plastic plate; 20798.

## R

radar cross-section measurements; antenna measurements; compact range; planar near-field measurements; precision parabolic reflector; 21215.  
 radial distribution function; shear; soft sphere fluid; viscosity; computer simulation; fluid structure; nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; 21237.  
 radiance temperature; tungsten; melting; normal spectral emittance; pulse heating; 21227.  
 radiance temperature at melting point; reference points; refractory elements; high temperature; 21369.  
 radiant; solar; space-heating; air-cooling; air leakage; energy; heat-recovery; insulation; measurement; office-building; 20961.  
 radiant energy; stoves; wall protection; walls; wood; chimneys; fire tests; flues; heating equipment; literature reviews; NBSIR 82-2506.  
 radiation; activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; neutron radiography; nondestructive evaluation; nuclear reactor; TN1160.  
 radiation; radiofrequency; regulation; safety; standards; bioeffects; dosimetry; electromagnetic; exposure; nonionizing; 21038.  
 radiation; radon; radon progeny; standards; states; thoron; calibration; measurements; NBS-GCR-82-394.  
 radiation; random uncertainty; significant figures; systematic uncertainty; units; data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); 20888.  
 radiation; red oak; surface temperature; absorption; ignition;

polymethylmethacrylate; 21305.  
 radiation; sodium atom; time development; transient effects; ionisation; linear polarization; monochromatic resonance; multiphoton; perturbation theory; 21075.  
 radiation; solid conduction; thermal conductivity; convection; foam; gas conduction; guarded-hot-plate; insulation; low temperature; NBSIR 82-1664.  
 radiation; solid fuel; absorption; ignition; 21314.  
 radiation; standards; traceability; calibration; definitions; hierarchy of standards; National Bureau of Standards; SP609; 1982 February. 11-17.  
 radiation; surface temperature; wood; absorption; CO<sub>2</sub> laser; decomposition; ignition; polymethacrylate; 20792.  
 radiation; turbulence; buoyancy; cross-correlation; diffusion flames; entrainment; heat flux; NBSIR 82-2473.  
 radiation; turbulence; ceilings; fire models; fire plumes; heat transfer; NBS-GCR-81-304.  
 radiation chemistry; thermistor; water; absorbed dose; calorimeter; convection; heat defect; J. Res. 87(3): 211-235; 1982 May-June.  
 radiation chemistry; vacuum ultraviolet; charge recombination; cyclopentane; photofragmentation; photoionization; quantum yields; 21243.  
 radiation crosslinking; teflon; crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; 20900.  
 radiation dose; device fabrication; electron-beam metallization; electron devices; ionizing radiation; microelectronics; process-related radiation damage; 21184.  
 radiation dosimetry; standards; calorimeter; cavity ionization chamber; extrapolation chamber; free-air chamber; ionizing radiation; measurement standards; SP609; 1982 February. 29-30.  
 radiation effects; semiconductor devices; VDMOS; drain-source resistance; electron devices; gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; power transistors; 21000.  
 radiation flux; combustion; degradation; polymers; polystyrene; pyrolysis; NBS-GCR-82-403.  
 radiation instrument performance; radiation measurements; regulatory standards; accuracy; bioassay performance; occupational radiation protection standards; performance criteria; quality control; SP609; 1982 February. 149-169.  
 radiation-matter interaction; Hanle effect; 21320.  
 radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; SP609; 1982 February. 171-178.  
 radiation measurement; radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; 20974.  
 radiation measurements; regulations; regulatory guides; traceability; enforcement; inspections; NRC; SP609; 1982 February. 129-133.  
 radiation measurements; regulatory standards; accuracy; bioassay performance; occupational radiation protection standards; performance criteria; quality control; radiation instrument performance; SP609; 1982 February. 149-169.  
 radiation mechanisms; stars; accretion; stars, magnetic; stars, neutron; x rays, binaries; 21171.  
 radiation pattern; relative antenna gain; antenna; base station; fixed antennas; law enforcement; performance standard; 20901.  
 radiation pattern; TEM cell; total radiated power; dipole moments; electrically small; interference source; leakage; phase measurements; power measurements; TN1059.  
 radiation pressure; resonances; light scattering; liquid droplets; microspheres; Mie theory; optical levitation; particle sizing; polarization ratio; 21054.  
 radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; SP609; 1982 February. 171-178.  
 radiation processing; radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; 20974.  
 radiation processing; radiochromic dyes; bleaching of dyes; dose rate; dosimetry; dyes; film dosimetry; gamma rays; humidity effects; leucocyanines; pulse radiolysis; 20844.  
 radiation processing; radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; electron



beam; gamma radiation; liquid dye solution; polar solvents; 20902.

radiation processing; radiochromic dyes; red Perspex; relative humidity effects; temperature effects; dosimetry; dyes; gamma radiation; plastic films; polymethyl methacrylate; 20975.

radiation processing; radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosanine; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; 20905.

radiation resistance; rectangular coaxial transmission line; TEM cell; variational method; Green's function; input impedance; probe antenna; *TN1054*.

radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; *SP609*; 1982 February. 171-178.

radiation sterilization; traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; 20974.

radiation theory; stimulated emission; atomic collisions; close-coupled scattering theory; dressed-atoms; inelastic cross-sections; laser; laser-induced collisions; 21347.

radiation therapy; absorbed dose; calibration; electron beam; high energy; ionization chamber; photon beam; 20894.

radiation therapy; calibration; field instruments; national radiation standards; *SP609*; 1982 February. 81-88.

radiation therapy; data handbook; diagnostic radiology; general physics; medical physics; nonionizing radiation; nuclear medicine; *H138*.

radiation therapy; survey; teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; *SP609*; 1982 February. 89-97.

radiation trapping; resonance radiation; fluorescence; ionization; laser ionization; metal vapors; 21289.

radiation yield; radiative stopping power; range; collision stopping power; electrons; positrons; *NBSIR 82-2550*.

radiative cooling; specific heat; thermal diffusivity; calorimetry; Fourier equation; *J. Res.* 87(6): 513-526; 1982 November-December.

radiative ignition; red oak; surface temperature; ignition; ignition surface temperature; polymethylmethacrylate; 21306.

radiative stopping power; range; collision stopping power; electrons; positrons; radiation yield; *NBSIR 82-2550*.

radiative transfer; line formation; line profiles; 20938.

radiative transfer; spectral line formation; stellar atmospheres; Voigt function; lineshape; 21148.

radiative transfer; stars, atmospheres; stars, circumstellar shells; stars, winds; 21147.

radical anions; radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; *NSRDS-NBS70*.

radicals; abstraction reactions; activation energies; bond-energy-bond-order; CN; ethynyl; 20781.

radicals; aromatic hydrocarbons; bond energies; ion-molecule reactions; proton affinities; 20950.

radicals; vinylidene; energetics; excited states; kinetics; methylene; 20783.

radioactive decay; alpha-particle-emission rates; liquid-scintillation counting; plutonium-239 (half life); plutonium isotopic abundances; 21246.

radioactivity; radionuclide; standard; traceability; calibration; environment; natural material; *SP609*; 1982 February. 117-127.

radioactivity; radiopharmaceutical; standards; traceability; assurance; measurements; *SP609*; 1982 February. 99-110.

radioactivity; radiopharmaceuticals; standards; traceability; absorbed dose; environment; 21355.

radioactivity; standards; system; calibration; intercomparisons; measurements; *SP609*; 1982 February. 31-37.

radioactivity measurements; radiopharmaceuticals; traceability; environmental measurements; international quality assurance; national quality assurance; natural-matrix reference materials; 20883.

radio astronomy; rotational spectrum; ethanol; intensities; interstellar molecules; microwave spectra; molecular constants; propionitrile; *JPCRD 11(2)*: 251-312; 1982.

radio astronomy; spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; 21185.

radiocarbon; accelerator mass spectrometry; atmospheric pollution; carbonaceous gases and particles; carbon cycle; chemical selectivity; climate; low-level counting; 21041.

radiocarbon; residential wood burning; urban particulates; vegetative burning; air pollution; biogenic/fossil carbon impact; field and slash burning; Portland aerosol characterization study; 20964.

radiochromic dye; alanine; biographic interferometry; calorimetry; ceric-cerous dosimetry; chemical dosimetry; dosimetry; ethanol chlorobenzene; high-dose measurements; lithium borate; lyoluminescence; 20889.

radiochromic dyes; anomalous dispersion; dimethyl sulfoxide; dosimetry; fibre optics; gamma-ray dosimetry; leuco cyanides; neutron dosimetry; optical waveguides; 20804.

radiochromic dyes; bleaching of dyes; dose rate; dosimetry; dyes; film dosimetry; gamma rays; humidity effects; leucocyanides; pulse radiolysis; radiation processing; 20844.

radiochromic dyes; radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; 20902.

radiochromic dyes; red Perspex; relative humidity effects; temperature effects; dosimetry; dyes; gamma radiation; plastic films; polymethyl methacrylate; radiation processing; 20975.

radiochromic dyes; triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosanine; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; 20905.

radiofrequency; regulation; safety; standards; bioeffects; dosimetry; electromagnetic; exposure; nonionizing; radiation; 21038.

radio frequency radiation; electromagnetic field; field intensity meter; isotropic antenna; 20885.

radiographic nondestructive testing; weld flaw inspection; flaw analysis from radiographs; flaw depth determinations; pipeline radiographic inspection; *SP621*; 1982 October. 165-173.

radiography; and ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; *NBSIR 82-2449*.

radiography; regulation; defect size measurement; fracture mechanics; girth welds; nondestructive evaluation; pipeline; 21189.

radiography; standards; traceable measurements; visual testing; acoustic emission; calibration; leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; 21398.

radiography; tire inspection; ultrasonics; visual-optical; acoustic emission; eddy currents; liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; 20957.

radiolysis; rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; *NSRDS-NBS70*.

radiolysis; triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; 20902.

radiometry; solar radiation; spectroradiometry; UV spectral measurements; atmospheric attenuation; atmospheric ozone; optical radiation measurements; *TN910-5*.

radionuclide; standard; traceability; calibration; environment; natural material; radioactivity; *SP609*; 1982 February. 117-127.

radiopharmaceutical; standards; traceability; assurance; measurements; radioactivity; *SP609*; 1982 February. 99-110.

radiopharmaceuticals; standards; traceability; absorbed dose; environment; radioactivity; 21355.

radiopharmaceuticals; traceability; environmental measurements; international quality assurance; national quality assurance; natural-matrix reference materials; radioactivity measurements; 20883.

radiotracer; antioxidants; diffusion; ethylene-vinyl acetate copolymers; food packaging; inverse gas chromatography; migration; oligomers; polyethylene; polypropylene; *NBSIR 82-2472*.

radium; standards; brachytherapy; calibration; cesium-137; dosimetry standards; iodine-125; iridium-192; 21311.

radon; radon daughters; environmental measurements; *SP609*; 1982 February. 135-143.

radon; radon progeny; standards; states; thoron; calibration; measurements; radiation; *NBS-GCR-82-394*.

radon; standards; calibration; measurement; quality assurance; 20834.

radon daughters; environmental measurements; radon; *SP609*; 1982 February. 135-143.

radon progeny; standards; states; thoron; calibration; measurements; radiation; radon; *NBS-GCR-82-394*.



rail flaw detection; crack detection; inspection interval; *SP621*; 1982 October. 69-90.

railroad accidents; railroad freight car; railroad testing; reliability; derailments; fatigue; freight car truck; *SP621*; 1982 October. 3-17.

railroad freight car; railroad testing; reliability; derailments; fatigue; freight car truck; railroad accidents; *SP621*; 1982 October. 3-17.

railroad testing; reliability; derailments; fatigue; freight car truck; railroad accidents; railroad freight car; *SP621*; 1982 October. 3-17.

rail structures; rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; *SP621*.

rail vehicles; reliability; transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; *SP621*.

rail vehicles; SEM fractography; cast steels; fatigue crack growth rates; fracture analysis; mechanical testing; microstructure; *SP621*; 1982 October. 33-45.

rain; reference materials; trace elements; acidity; acid rain; chemical analysis; conductance; pH; precipitation; *NBSIR 82-2581*.

Raman microprobe; Raman spectroscopy; vibrational analysis; hexagonal urea lattice; inclusion compounds; microanalysis; normal alkanes; 20996.

Raman scattering; straight chain section; accordion-type oscillation; drawn polyethylene; gauche defect; 20790.

Raman spectra; silicon; spectra; thermal annealing; annealing; boron; ion implantation; laser annealing; local mode; optical spectra; phonons; 21091.

Raman spectra of monolayers; surface enhanced Raman spectroscopy (SERS); surface plasmons; surface roughness; adsorbed monolayers; 21068.

Raman spectroscopy; silver electrode; surface-enhanced Raman spectroscopy; adsorption; electrode processes; N-methylpyridinium iodide; pyridine derivatives; 21262.

Raman spectroscopy; vibrational analysis; hexagonal urea lattice; inclusion compounds; microanalysis; normal alkanes; Raman microprobe; 20996.

random access; computer indexing; data base; directory look-up; information retrieval; interactive processing; *TN1167*.

random uncertainty; significant figures; systematic uncertainty; units; data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; 20888.

Raney nickel; vibrational spectroscopy; chemisorption; hydrogen; neutron inelastic scattering; 21295.

range; collision stopping power; electrons; positrons; radiation yield; radiative stopping power; *NBSIR 82-2550*.

ranges of application and limitations; Schottky barrier diodes; SIMS and C-V profile comparisons; automatic C-V profiler analyses; carrier depth distributions; differential capacitance-voltage profiling; ion implantation; *SP400-71*.

rapid; wear-metal analysis; colorimetric iron kit; iron; jet engine oil; portable; *SP640*; 1982 October. 455-465.

rapid fiber analysis; asbestos fibers; light scattering; magnetic alignment; magnetic filtration; *SP619*; 1982 March. 108-120.

rapid frequency scanning; ring dye laser; single frequency dye laser; tuneable laser; frequency scanned laser; 20791.

rapid solidification; amorphous alloys; coupled growth; eutectic solidification; metallic glasses; palladium-copper-silicon alloys; 21190.

rapid solidification; stability; surface melting; aluminum-silver alloys; cellular growth; electron beam; interface velocity; 21263.

rapid transit; steel frames; welding; brittle fracture; failure; fatigue; *SP621*; 1982 October. 110-129.

rare-earth; absolute; calibration; continuum; irradiance; plasma; 21016.

rare earths; crystal fields; ferromagnetism; manganese compounds; neutron diffraction; profile refinement; 20944.

rare earths; scandium alloys; spin glass; antiferromagnetism; critical fields; ferromagnetism; 21129.

rare gases; synchrotron radiation; asymmetry parameter; autoionization; branching ratios; innershell resonances; photoelectron spectroscopy; 21291.

rare-gas halide; transition moments; blue-green laser; effective core potentials; excimer; 21309.

rare gas halides; rate coefficients; excimer lasers; fluorescence branching ratios; kinetics; 21299.

rare gas mixtures; spectra; transient dipoles; collision-induced absorption; collision-induced light scattering; far infrared absorption; induced dipole; line shape; 21173.

rare gas mixtures; spectral behavior; absorption spectrum; atomic masses; collision-induced absorption; concentration; correlation function; density; 21007.

rate coefficient; air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photo-absorption cross section; photochemistry; quantum yield; *JPCRD 11(2)*: 327-496; 1982.

rate coefficients; excimer lasers; fluorescence branching ratios; kinetics; rare gas halides; 21299.

rate constant; resonance fluorescence; stratospheric ozone; chemical kinetics; flash photolysis; hydroxyl radicals; nitric acid; 21040.

rate constants; abstraction; ethane; ethane-d<sub>6</sub>; ethynyl radicals; 20780.

rate constants; reactivity; soot; ion cyclotron resonance; ion-molecule; isomers; 21323.

rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; *NSRDS-NBS72*.

rates; alkyl radicals; aminoalkyl radicals; aqueous solution; carboxyalkyl radicals; chemical kinetics; electron transfer; haloalkyl radicals; hydroxyalkyl radicals; photolysis; radical anions; radiolysis; *NSRDS-NBS70*.

rate structures; water conservation; consumer education; energy conservation; feedback; incentives; metering; *NBSIR 80-2119*.

rating; solar; standards; testing; energy; heat transfer; hot water; measurement; 21264.

rating procedure; seasonal cost of operation; test method; central air conditioners; heat pumps; *NBSIR 81-2434*.

Rayleigh scattering; tabulation; water; x rays; coherent scattering; cross section; form factor; *JPCRD 11(4)*: 1091-1098; 1982.

Rayleigh wave; transducer; ultrasonic; acoustic emission; elastic wave; nondestructive evaluation; 21098.

reaction intermediate; x-ray diffraction; crystal structure; inner salt; iodonium compound; ionic bonding; 21268.

reactivity; soot; ion cyclotron resonance; ion-molecule; isomers; rate constants; 21323.

reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; 21177.

real gas; reference measurement conditions; calorific value; enthalpy of combustion; estimation from composition; gaseous fuel mixtures; heating value; hydrocarbon gases; ideal gas; *NBSIR 82-2401*.

real time; synchrotron; topography; x-ray image magnification; multichannel diffraction; 21259.

real-time control; vibration control; vibration isolation; active vibration control; Michelson interferometer; optical path-length correction; phase comparator; 21403.

real-time system; documentation; operations manual; *SP500-94*; 1982 October. 53-57.

recalescence; solidification; undercooling; amorphous; cooling rate; crystalline; dendrites; interfaces; microcrystalline; nucleation; 21090.

reciprocal aid; recovery center; redundant facilities; shared contingency facility; backup operations; contingency planning; disaster recovery; empty shell; *SP500-95*; 1982 October. 439-441.

reciprocity calibration; torsional vibration; absolute measurement; accelerometer calibration; angular vibration; interferometer; 20967.

recirculation; soot formation; diffusion flames; flame stabilization; laser-induced fluorescence; polycyclic aromatic hydrocarbons; 21343.

reclaiming; re-refining; used oil; waste oil; lubricants; oil recycling; petroleum; pollution control; 21383.

recognition; accrediting agencies; laboratory; *SP632*; 1982 March. 81-91.

recovered/recycled materials; resource recovery; bid-modifier; disposal costs; PAR factor; procurement; purchasing; *NBS-GCR-82-400*.

recovery actions; ADP security; backup operations; computer security; contingency planning; emergency response; Federal Information Processing Standards Publication; *SP500-85*.

recovery center; redundant facilities; shared contingency facility; backup operations; contingency planning; disaster recovery; empty shell; reciprocal aid; *SP500-95*; 1982 October. 439-441.

rectangular coaxial transmission line; TEM cell; variational method; Green's function; input impedance; probe antenna; radiation resistance; *TN1054*.

rectification; alternating voltage; charge-transfer; corrosion;



electrochemistry; frequency analysis; 20886.

rectifier; solid state devices; transistor; electronics; noise; photon detector; *TN1169*.

recursive least squares algorithm; self-tuning control algorithm; adaptive control; air handling unit; direct digital control; energy management and control systems; HVAC system control; parameter estimator; PI-controller; *NBSIR 82-2591*.

recycled oil; burner fuel; fuel oil; petroleum; petroleum testing; processed used oil; 21394.

recycled oil; re-refined oil; test procedures; basestock; engine lubricants; lubricating oil; motor oil; petroleum oil; 20990.

recycled oil; re-refining; used oil recycling; additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; petroleum; petroleum testing; 21397.

recycling; resource recovery; rubber; textiles; directory; ferrous metals; glass; nonferrous metals; paper; plastic; procurement; purchasing; *NBS-GCR-82-366*.

recycling; resource recovery; standards; steel; ferrous scrap; iron; municipal solid waste; 21358.

red oak; surface temperature; absorption; ignition; polymethylmethacrylate; radiation; 21305.

red oak; surface temperature; ignition; ignition surface temperature; polymethylmethacrylate; radiative ignition; 21306.

red Perspex; relative humidity effects; temperature effects; dosimetry; dyes; gamma radiation; plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; 20975.

reduced cell; crystallography; data analysis; determinative ratios; FORTRAN program; metric symmetry; 21269.

reduced maintenance; silicone brake fluid; U.S. Army; long life; *SP640*; 1982 October. 162-169.

reduction; terbium; glass; luminescence; melts; oxidation; 21315.

redundant facilities; shared contingency facility; backup operations; contingency planning; disaster recovery; empty shell; reciprocal aid; recovery center; *SP500-95*; 1982 October. 439-441.

re-entry vehicles; reliability assessment; automatic test system; computer-automated; *SP640*; 1982 October. 216-221.

reference data; chemical properties; critical tables; data evaluation; physical properties; 21389.

reference intensities; standard; x-ray diffraction; crystal structure; densities; lattice constants; powder patterns; *Monogr. 25, Section 19*.

reference materials; semiconductors; silicon; standard reference materials; measurements; metrology; 20829.

reference materials; standards; trace analysis; accuracy; high purity materials; instrumental neutron activation analysis; precision; 20997.

reference materials; trace elements; acidity; acid rain; chemical analysis; conductance; pH; precipitation; rain; *NBSIR 82-2581*.

reference measurement conditions; calorific value; enthalpy of combustion; estimation from composition; gaseous fuel mixtures; heating value; hydrocarbon gases; ideal gas; real gas; *NBSIR 82-2401*.

reference method; serum sodium analysis statistics; flame atomic emission spectrometry; interlaboratory performance; 21206.

reference method; statistical analysis; clinical analysis; glucose in serum; glucose reference method; isotope dilution/mass spectrometry; *SP260-80*.

reference points; refractory elements; high temperature; radiance temperature at melting point; 21369.

reference standards; standard capacitors; standard qualification; calibration; measurement assurance; *TN1161*.

reference standards; standard capacitors; standard qualification; transfer standards; calibration; measurement assurance; measurement assurance programs; *TN1162*.

reference waveform generators; rise time; time domain measurements; transfer standards; transition duration; waveform generation; waveform measurements; calibration; *SP634*; 1982 June. 69-88.

refinement; ribonuclease; amide protection; flexibility; hydrogen exchange; protein structure; 21137.

reflectance; refractive index; dielectric constants; ellipsometry; niobium; optical constants; 21183.

reflectance; selected ordinate; solar absorber materials; solar cover plates; transmittance; weighted ordinate; air mass; ASTM E 424; integrating sphere spectrophotometer; *NBSIR 81-2448*.

reflectance specular; reflectance standards; second surface mirrors; solar reflectance; specular spectral reflectance; aluminum mirrors; directional specular reflectance; *SP260-79*.

reflectance standards; second surface mirrors; solar reflectance; specular spectral reflectance; aluminum mirrors; directional specular reflectance; reflectance specular; *SP260-79*.

reflected neutrons; scattered neutrons; background; calibration; californium neutrons; personnel monitoring; 20966.

reflection coefficient; Riccati equation; surface reflections; wave impedance; electromagnetic waves; graded materials; inhomogeneous media; helium; optical reflections; *TN1171*.

reflection errors; anechoic chamber; calibrations; 20898.

reflection imaging; scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; *NBS-GCR-80-204*.

reflectivity; resolving power; synchrotron radiation; 1 keV photon energy region; beryl; KAP; metallic multilayers; 21088.

reflectometry; rf characteristics; transmission; treeing; aging; dielectric; distribution; electrical failure; polyethylene; 21140.

refractive index; dielectric constants; ellipsometry; niobium; optical constants; reflectance; 21183.

refractive index; scattering matrix; thin film; transmittance extrema; electro-optic modulation; hydrogenated amorphous silicon; optical transmittance; *NBSIR 81-1652*.

refractivity of air; wavelength of light in air; air density; index of refraction of air; 21276.

refractories; alloys; coal conversion; coal gasification; corrosion; erosion; materials properties; mechanical properties; physical properties; *SP642*.

refractory elements; high temperature; radiance temperature at melting point; reference points; 21369.

refrigerator; Stirling cycle; superconducting devices; cryocooler; cryogenics; low temperature; *TN1049*.

refuge; building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; handicapped; life safety; *NBS-GCR-82-383*.

refuse; refuse-derived-fuel; 25 gram capacity flow calorimeter; enthalpy of combustion; flow calorimetry; municipal solid waste; *NBSIR 82-2457*.

refuse-derived fuel; sample characterization; sample variability; calorific value; flow calorimetry; kilogram-size samples; municipal solid waste; *NBSIR 82-2491*.

refuse-derived-fuel; 25 gram capacity flow calorimeter; enthalpy of combustion; flow calorimetry; municipal solid waste; refuse; *NBSIR 82-2457*.

régime I; régime II; reptation; crystallization; fraction; friction coefficient; growth rate; polyethylene; 21158.

régime II; reptation; crystallization; fraction; friction coefficient; growth rate; polyethylene; régime I; 21158.

registration of servicepersons; unit pricing; Weighmaster Law; basic weights and measures law; method of sale of commodities; open dating; packaging and labeling; *H130, 1983 Edition*.

regression; statistical methods; structural; errors in variable; functional; large sample, convex; *J. Res. 87(1): 67-70*; 1982 January-February.

regression analysis; safety; shear properties; splitting tensile strength; statistical analysis; age-strength relation; building codes; compressive strength; concretes; 21150.

regularities; similarities; Stark broadening; isolated lines; neutral and ionic spectra; 21365.

regularization; first kind integral equation; ill-posed problems; Lanczos algorithm; 20778.

regulation; defect size measurement; fracture mechanics; girth welds; nondestructive evaluation; pipeline; radiography; 21189.

regulation; research and development; technology policy; administrative experiments; economic assistance; innovation; procurement; *NBS-GCR-ETIP 82-100*.

regulation; safety; standards; bioeffects; dosimetry; electromagnetic; exposure; nonionizing; radiation; radiofrequency; 21038.

regulations; regulatory guides; traceability; enforcement; inspections; NRC; radiation measurements; *SP609*; 1982 February. 129-133.

regulations; standards; traceability; type testing; calibrations; codes of practice; ionizing radiation; *SP609*; 1982 February. 19-27.

regulatory experiments; drug development; drug regulation; innovation; post-marketing surveillance; *NBS-GCR-ETIP 82-99*.

regulatory guides; traceability; enforcement; inspections; NRC; radiation measurements; regulations; *SP609*; 1982 February. 129-133.

regulatory process; simulation of human behavior; building codes; building fires; computer-aided design; computer simulation;



emergency egress; fire research; human performance; modeling; pedestrian movement; 20911.

regulatory standards; accuracy; bioassay performance; occupational radiation protection standards; performance criteria; quality control; radiation instrument performance; radiation measurements; *SP609*; 1982 February. 149-169.

rehabilitation; building accessibility; building rehabilitation guidelines; code enforcement; earthquake requirements; energy conservation; existing buildings; 21385.

rehabilitation; renovation; applied economics; building codes; health and safety; housing; mathematical programming; *NBSIR 81-2416*.

rehydration; solar; calcium-aluminum hydrates; calorimetry; dehydration; energy storage; *NBSIR 82-2531*.

relation; relational model; Relational Task Group; American National Standards Institute; computer standards; DBMS; database management; database standards; Data Base System Study Group; query language; *NBS-GCR-82-379*.

relational; standards; database management; DBMS; functional specification; mandatory requirements; optional requirements; procurement; *NBS-GCR-82-372*.

relational data model; schema design; database design; database management; database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; *NBS-GCR-82-390*.

relational model; Relational Task Group; American National Standards Institute; computer standards; DBMS; database management; database standards; Data Base System Study Group; query language; relation; *NBS-GCR-82-379*.

Relational Task Group; American National Standards Institute; computer standards; DBMS; database management; database standards; Data Base System Study Group; query language; relation; relational model; *NBS-GCR-82-379*.

relative antenna gain; antenna; base station; fixed antennas; law enforcement; performance standard; radiation pattern; 20901.

relative humidity; sorption thermodynamics; absorption; adsorption; dew point; hygrometer; kinetics; microelectronic package; moisture; moisture level; *SP400-72*; 1982 April. 184-200.

relative humidity effects; temperature effects; dosimetry; dyes; gamma radiation; plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; 20975.

relative photon-emission probabilities; compilation; efficiency data; half lives; measurement uncertainties; photon probabilities per decay; *SP626*.

relativistic effects; spectroscopy; doublet inversions; 21057.

relativity; Eötvös experiment; fibers; general relativity; gravitation; null experiments; 20954.

relativity; satellite clocks; SI second; synchronization; syntonization; time scales; coordinate time; frequency standards; international atomic time; 21188.

relaxation; adsorption; many-body theory; photoemission; 21151.

relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients; equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; 21208.

relaxation; supercooling; Suzuki's scaling; time-dependent growth rate; unstable; nonlinear; 21399.

relaxation; velocity autocorrelation; distribution functions; hard rods; molecular dynamics; non-ergodic; 21283.

relaxation theory; Stark broadening; Balmer lines; ion dynamics; Lyman series; plasma broadening; plasma theory; 21368.

relaxation time; sensitivity; slotted aloha; throughput; transition matrix; carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; protocols; *SP500-95*; 1982 October. 365-373.

reliability; derailments; fatigue; freight car truck; railroad accidents; railroad freight car; railroad testing; *SP621*; 1982 October. 3-17.

reliability; humidity; hybrids; microcircuits; moisture; moisture sensors; *SP400-72*; 1982 April. 178-183.

reliability; risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; 21177.

reliability; risk analysis; valve; database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; 21176.

reliability; service life; wood; durability; duration of load; life data; life distribution; 20809.

reliability; silicon nitride; structural ceramics; deformation maps; high temperatures; proof testing; *NBSIR 81-2445*.

reliability; standard; test chip; test structure; custom; integrated circuits; multifunction; parametric tester; 20835.

reliability; standard packages; humidity; mass spectrometry; moisture sensors; packaging; *SP400-72*; 1982 April. 19-31.

reliability; transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; *SP621*.

reliability; water vapor; derivative spectroscopy; diode laser; humidity; infrared; microcircuits; moisture; *SP400-72*; 1982 April. 105-109.

reliability assessment; automatic test system; computer-automated; re-entry vehicles; *SP640*; 1982 October. 216-221.

reliability assessment; fault detection/location system; lubrication; maintenance; maintenance management; maintenance technology; manpower utilization; *SP640*.

Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); *SP640*; 1982 October. 235-254.

reliability of semiconductor devices; semiconductor devices; analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; moisture generators; moisture sensors; quality control; *SP400-72*.

remmeter; room return; air scatter; calibration; californium; dose equivalent; dosimeter; neutron; *SP633*.

remote; response time; series/1; sidestreaming; simulated commands; 327X emulator; accurate data; end user; host independent; monitor; network; performance; *SP500-95*; 1982 October. 401-407.

remote access of data; semantic integrity; constraint; database; database management system; data correctness; integrity; networks; 21124.

Remote Command Data Link; electromagnetic pulse; fiber optics; Marx generators; *SP628*; 1982 June. 310-315.

Remote Command Data Link; EMP simulator; Marx erection time; Marx generators; *SP628*; 1982 June. 316-319.

remote sensing of atmosphere; corrugated feed; near-field scanning application; offset; antenna; 21186.

remote terminal emulation; remote terminal emulator; system under tests; interactive system; performance evaluation; *SP500-95*; 1982 October. 409-413.

remote terminal emulation; system design; teleprocessing systems; testing; external test driver; performance evaluation; *SP500-95*; 1982 October. 415-421.

remote terminal emulator; system under tests; interactive system; performance evaluation; remote terminal emulation; *SP500-95*; 1982 October. 409-413.

renormalization group; Boson field theory; high-temperature series expansions; hyperscaling relations; Ising ferromagnet; Padé and integral approximants; 21080.

renovation; applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; integer programming; mathematical programming; nursing homes; optimization; 20909.

renovation; applied economics; building codes; health and safety; housing; mathematical programming; rehabilitation; *NBSIR 81-2416*.

rental apartment complexes; waste flow; water conservation; watersaving devices; controlled installation; leak detection; preventive maintenance; *SP624*; 1982 June. 169-171.

reorientation; tunnel states; deuterated; methyl group; neutron scattering; nitromethane; 20895.

repairability; sandwich structure; testing; composite materials; laminate structure; maintenance; *SP640*; 1982 October. 364-378.

repassivation; surface modification; breakdown of passivity; corrosion; electrochemistry; passivity; 20928.

representation theory; generalized inverses; Hamiltonian mechanics; Lie algebras; nonlinear oscillations; normalization; *NBSIR 82-2541*.

representative workload; system monitoring; workload characterization; workload measurement; computer accounting; *SP500-95*; 1982 October. 111-120.

reptation; crystallization; fraction; friction coefficient; growth rate; polyethylene; régime I; régime II; 21158.

requirements; cost parameters; database management; data management evaluation; DBMS; decision model; preference



parameters; *NBS-GCR-82-373*.

requirements; cost parameters; DBMS; database management; data management; data management evaluation; decision model; preference parameters; *NBS-GCR-82-374*.

requirements; cost parameters; DBMS; database management; data management; data management evaluation; decision model; preference parameters; *NBS-GCR-82-375*.

requirements; retrieval; Tharp's algorithm; assignment; Brent's algorithm; double hashing; *21248*.

requirements analysis; feature analysis; guidelines; local area networks; local network specification; *SP500-96*.

requirements documentation; software management; software maintenance; software requirements; *SP500-94*; 1982 October. 265-273.

re-refined oil; test procedures; basestock; engine lubricants; lubricating oil; motor oil; petroleum oil; recycled oil; *20990*.

re-refining; used oil; waste oil; lubricants; oil recycling; petroleum; pollution control; reclaiming; *21383*.

re-refining; used oil recycling; additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; petroleum; petroleum testing; recycled oil; *21397*.

research; state-of-the-art; applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; *NBSIR 82-2505*.

research; steam; thermal response; valve; air conditioning; building systems; computer; control; heat exchanger; modeling; monitoring; *21048*.

research and development; robot; state-of-the-art; applications; forecast; Japan; overview; *NBSIR 82-2479*.

research and development; technology policy; administrative experiments; economic assistance; innovation; procurement; regulation; *NBS-GCR-ETIP 82-100*.

research facility; automated machining; hierarchical control; manufacturing research; *21378*.

research needs; residual stress; standards; stress measurement; terminology; ultrasonics; x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; photoelasticity; *21344*.

residential; scenario; smoldering; cigarettes; codes; escape; fatalities; fire; flaming; flashover; nonresidential; *20775*.

residential buildings; room fires; building fires; fire resistance; fire tests; flow measurement; gas temperatures; heat release rate; interior finishes; *NBSIR 80-2120*.

residential buildings; smoke detectors; sprinkler systems; cost benefit analysis; decision analysis; fire losses; fire safety; *NBSIR 82-2551*.

residential buildings; solar data base; solar energy system; solar hot water, space heating and cooling; automatic data processing; computer reports; grant data; *NBSIR 81-2376*.

residential buildings; solar data base; solar energy systems; solar heating and cooling; automatic data processing; data base; *NBSIR 81-2369*.

residential buildings; solar data energy system; solar heating and cooling; automatic data processing; data dictionary/directory; *NBSIR 81-2357*.

residential buildings; sprinkler systems; water; corrosion; friction reduction; pipes; potable water; pressure reduction; *NBS-GCR-82-399*.

residential development; water conservation; land use planning; *SP624*; 1982 June. 103-111.

residential energy consumption; space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; *TN1156*.

residential energy consumption; weatherization; Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization; *BSS144*.

residential fires; rural fires; fire cause; fire data; fire fatalities; fire statistics; firefighting equipment; *NBSIR 82-2519*.

residential furnaces; room temperature; thermal response factors; thermostat control; burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; *20903*.

residential water conservation; water-saving plumbing devices; appliances; conservation programs; *SP624*; 1982 June. 193-196.

residential water conservation devices; water conservation; water resources planning; water system leak detection; in-school education; *SP624*; 1982 June. 401-407.

residential water savings; retrofitting; water conservation device; low-water-using bathroom fixtures; *SP624*; 1982 June. 329-337.

residential water savings devices; device installation programs; in-school education programs; *SP624*; 1982 June. 449-452.

residential water use; sanitary performance; surface cleansing; test methods; volumetric efficiency; waste removal; water closets; *SP624*; 1982 June. 273-280.

residential wood burning; urban particulates; vegetative burning; air pollution; biogenic/fossil carbon impact; field and slash burning; Portland aerosol characterization study; radiocarbon; *20964*.

residual stress; energy dispersive diffractometry; high energy photons; *20887*.

residual stress; energy dispersive diffractometry; high energy photons; *21350*.

residual stress; standards; stress measurement; terminology; ultrasonics; x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; *21344*.

residual stress; stress analysis; x-ray diffraction; diffraction; high-energy x-rays; internal stress; neutron diffraction; nondestructive evaluation; *21359*.

residual stress; stress measurements; ultrasonics; x-ray diffraction; Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; *20926*.

resistance; resistivity; review; alloys; conductivity; electrical property; metals; polymers; *TN1053*.

resistance standard; silicon MOSFETs; two-dimensional electron gas; fine-structure constant; Hall effect; Landau levels; *21220*.

resistivity; coal slag; conductivity; high temperature; impedance; *21182*.

resistivity; review; alloys; conductivity; electrical property; metals; polymers; resistance; *TN1053*.

resistivity profiles silicon; spreading resistance; thyristor; aluminum-doped silicon; dopant profiles; gallium doped silicon; *21083*.

resistor dividers; response time; voltage measurement; comparative measurements; design; dividers; impulse measuring systems; *SP628*; 1982 June. 34-45.

resolution; solid angle; spectrometer; momentum acceptance; nucleon; pair correlation function; *21402*.

resolving power; synchrotron radiation; 1 keV photon energy region; beryl; KAP; metallic multilayers; reflectivity; *21088*.

resonance; sodium; transport; backscattering; experiment; forward scattering; quenching; *20953*.

resonance; ytterbium; Auger; core-holes; mixed-valence; photoionization; *21105*.

resonance fluorescence; stratospheric ozone; chemical kinetics; flash photolysis; hydroxyl radicals; nitric acid; rate constant; *21040*.

resonance ionization spectroscopy; trace analysis of solids; two-photon absorption spectroscopy; laser ablation; laser-produced vaporization; laser-solid interaction; plasma production and heating by laser beam; pulsed-dye laser application; *20922*.

resonance line; absolute cross section; crossed beams; electron-ion collisions; excitation; Ga II; *21317*.

resonance radiation; fluorescence; ionization; laser ionization; metal vapors; radiation trapping; *21289*.

resonances; light scattering; liquid droplets; microspheres; Mie theory; optical levitation; particle sizing; polarization ratio; radiation pressure; *21054*.

resonances; satellite theory; algebra by computer; Birkhoff normalisation; celestial mechanics; *20777*.

resonant scattering; dense atomic vapors; electrons; ionization; laser excitation; *21290*.

resource appraisal; sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; *SP631*.

Resource Conservation and Recovery Act; State measurement needs; test protocols; analytical procedures; hazardous waste management; lab procedures; model manual; monitoring; *NBS-GCR-81-355*.

Resource Conservation and Recovery Act; test protocols; Texas; training; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-352*.

Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; Mississippi; *NBS-GCR-81-353*.

Resource Conservation and Recovery Act; test protocols; training;



analytical procedures; hazardous waste management; lab procedures; Oklahoma; *NBS-GCR-81-350*.

Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; Pennsylvania; *NBS-GCR-81-351*.

Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; Louisiana; *NBS-GCR-81-349*.

Resource Conservation and Recovery Act; test protocols; training; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-348*.

Resource Conservation and Recovery Act; test protocols; training; Virginia; analytical procedures; hazardous waste management; lab procedures; *NBS-GCR-81-354*.

resource management; statistical analysis; workload characterization; capacity planning; job accounting; *SP500-95*; 1982 October. 259-273.

resource measurement facilities; simulation; supercomputers; workload characterization; benchmarking; capacity planning; chargeback systems; computer performance management systems; queueing models; *SP500-95*.

resource recovery; bid-modifier; disposal costs; PAR factor; procurement; purchasing; recovered/recycled materials; *NBS-GCR-82-400*.

resource recovery; rubber; textiles; directory; ferrous metals; glass; nonferrous metals; paper; plastic; procurement; purchasing; recycling; *NBS-GCR-82-366*.

resource recovery; solid waste management; steam production; destruct heating; electricity production; energy recovery; incineration; New York City; *NBS-GCR-82-409*.

resource recovery; solvent recovery; steel manufacturing; electroplating; Great Lakes region; hazardous waste management; paint manufacturing; *NBS-GCR-82-405*.

resource recovery; South Carolina; cellulosic insulation; Florida; Georgia; newspaper recovery; North Carolina; *NBS-GCR-82-371*.

resource recovery; standards; steel; ferrous scrap; iron; municipal solid waste; recycling; *21358*.

resource-sensitive job scheduling; service levels; SMF exits; workload scheduling; batch; DSNAMES ENQUEUE conflict management; MVS SRM; *SP500-95*; 1982 October. 297-311.

response time; series/1; sidestreaming; simulated commands; 327X emulator; accurate data; end user; host independent; monitor; network; performance; remote; *SP500-95*; 1982 October. 401-407.

response time; voltage measurement; comparative measurements; design; dividers; impulse measuring systems; resistor dividers; *SP628*; 1982 June. 34-45.

restoration coatings; accelerated bathtub exposure cycle; performance criteria for restoration coatings; porcelain enamel restoration; *NBSIR 82-2553*.

restorative; wear; amalgam; apparatus; composite; dental; instrumentation; pin and disc; *20916*.

restrained refinement; single crystals; x rays; joint refinement; macromolecular structures; neutron; *21136*.

restricted random walk; absorbing points; lattice random walk; mean occupation time; polymer adsorption; probability of first return; *20826*.

retained austenite standard; standard reference material; x-ray fluorescence; austenite in ferrite; powder metallurgy; quantitative microscopy; *SP260-78*.

retained austenite standard; standard reference material; x-ray fluorescence; austenite in ferrite; powder metallurgy; quantitative microscopy; *SP260-76*.

retardant; smolder; thermogram; cellulose; combustion; flame; inhibition; inorganic; powder; pyrolysis; *20799*.

retrieval; Thorp's algorithm; assignment; Brent's algorithm; double hashing; requirements; *21248*.

retrofitting; water conservation device; low-water-using bathroom fixtures; residential water savings; *SP624*; 1982 June. 329-337.

revenue metering; calibration; CCVT; EHV substations; error sources; high voltage measurements; *NBSIR 81-2360*.

reverberation chambers; transverse electromagnetic cells; buried electromagnetic enclosures; electromagnetic compatibility measurements (EMC); low-Q chambers; *21061*.

reverse-bias second breakdown; testing; voltage; clamping; diode recovery; high power measurements; high voltage; overshoot; power semiconductors; *20849*.

reversible; salts; croconates; dicyanomethylene; electrochemical; electron-transfer; mechanism; oxidation; *21103*.

review; additives; antioxidants; basestocks; chemiluminescence; fuels; hydrocarbons; kinetic methods; lubricating oils; materials testing; oxidation; petroleum products; *NBSIR 82-2490*.

review; alloys; conductivity; electrical property; metals; polymers; resistance; resistivity; *TN1053*.

review infrared multiphoton dissociation;  $\text{CF}_2\text{HCl}$ ;  $\text{CF}_3\text{CFCl}$ ; infrared excitation; multiphoton dissociation; product state distributions; *21334*.

rf characteristics; transmission; treeing; aging; dielectric; distribution; electrical failure; polyethylene; reflectometry; *21140*.

RFP; statement of work; acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; portability; program inventory; *SP500-90*.

Rh-Fe; SQUIDS; superconducting fixed points; thermometry; Josephson effect; *21035*.

rhodium; carbon; carbon monoxide; chemisorption; dissociation; *20962*.

rhodium-iron thermometers; thermistors; EPT-76; germanium resistance thermometers; IPTS-68; magnetic thermometers; NQR thermometers; *20933*.

Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111);  $\text{CH}_4$ ; decomposition; heterogeneous catalysis; hydrogen; methanation;  $\text{NH}_3$ ; Ni(100); Ni(111); oxygen; *20825*.

ribonuclease; amide protection; flexibility; hydrogen exchange; protein structure; refinement; *21137*.

ribonuclease; x-ray diffraction; active site; charge relay; enzymes; protein structure; *20893*.

ribonuclease-S; semi-synthetic proteins; x-ray methods; active site; hydrogen bonds; protein structure; *20914*.

Ricatti equation; surface reflections; wave impedance; electromagnetic waves; graded materials; inhomogeneous media; jellium; optical reflections; reflection coefficient; *TN1171*.

Rietveld method; solid solution; tantalum oxide; lithium tantalate; neutron diffraction; powder method; *21157*.

ring dye laser; single frequency dye laser; tuneable laser; frequency scanned laser; rapid frequency scanning; *20791*.

riparian doctrine; water law; conservation; *SP624*; 1982 June. 17-26.

ripple; sand; sea bed; stress; time dependent; unsteady; water tunnel; waves; drag; oscillatory flow; phase dependent; *21332*.

rise time; time domain measurements; transfer standards; transition duration; waveform generation; waveform measurements; calibration; reference waveform generators; *SP634*; 1982 June. 69-88.

risk analysis; safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; *NBSIR 82-2562*.

risk analysis; statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; *21177*.

risk analysis; valve; database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; *21176*.

rms value; sampling; signal period; algorithm; converter; distortion; microcomputer; *TN1159*.

robot; state-of-the-art; applications; forecast; Japan; overview; research and development; *NBSIR 82-2479*.

robotics; robots; automation; computer aided manufacturing; glossary; materials handling; *NBSIR 81-2340*.

robots; automation; computer aided manufacturing; glossary; materials handling; robotics; *NBSIR 81-2340*.

robots; safety; sensors; ultrasonic; echo-ranging transducer; industrial robots; *20977*.

Rogowski coils; cavity current monitors; current measurements; current viewing resistors; high di/dt particle beam accelerator; *SP628*; 1982 June. 266.

Rogowski coils; current monitors; current probe; current pulses; pulse generators; *SP628*; 1982 June. 289-299.

Rogowski coils; current sensors; fluxmeters; pulsed current measurements; *SP628*; 1982 June. 175-193.

roller bearings; thermal analysis; bearing failure; bearing reliability; condition monitoring; *SP640*; 1982 October. 295-325.

rolling element bearings; rolling fatigue; spalling; filtration; gearboxes; helicopter transmission; pitting; *SP640*; 1982 October. 326-347.

rolling fatigue; spalling; filtration; gearboxes; helicopter transmission;



pitting; rolling element bearings; *SP640*; 1982 October. 326-347.  
 roofing; thermal conductance; thermal conductivity; thermal resistance; built-up roofing; insulation; moisture; *21354*.  
 roofing bitumens; asphalt viscosity; bitumen cooling time; *20843*.  
 roofing fire resistance; roofing fire tests; solar collectors; fire tests; *NBSIR 81-2344*.  
 roofing fire resistance; roofing fire tests; solar collectors; fire tests; *21134*.  
 roofing fire tests; solar collectors; fire tests; roofing fire resistance; *NBSIR 81-2344*.  
 roofing fire tests; solar collectors; fire tests; roofing fire resistance; *21134*.  
 roofing membranes; single-ply roofing; tensile strength; test methods; elongation; exposure conditions; membrane properties; *20841*.  
 room fire; entrainment; flame angle; openings; plume; *20810*.  
 room fires; building fires; fire resistance; fire tests; flow measurement; gas temperatures; heat release rate; interior finishes; residential buildings; *NBSIR 80-2120*.  
 room fires; calorimeters; fire tests; heat release rate; oxygen consumption; *NBSIR 81-2427-1*.  
 room fires; ceilings; diffusion flames; entrainment; fire plumes; flame size; flame structure; *NBS-GCR-82-402*.  
 room fires; compartment fires; correlations; corridor tests; fire growth; fire tests; flammability; flashover; interior finishes; *NBSIR 82-2525*.  
 room fires; scale models; fire growth; flashover; heat release rate; physical modeling; *NBSIR 81-2453*.  
 room fires; sidewall sprinkler systems; thermal response; automatic sprinklers; compartment fires; fire safety; life safety; *NBSIR 82-2521*.  
 room fires; smoke movement; tenability limits; combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; *NBSIR 82-2578*.  
 room fires; smoldering; fabric flammability; fire models; fire tests; home fires; hospitals; mattresses; nursing homes; *NBSIR 81-2440*.  
 room fires; standards; building fires; building materials; committees; fire tests; flashover; *21118*.  
 room fires; thermal degradation; ceilings; charring; compartment fires; corridors; flame spread; polymers; *NBS-GCR-82-377*.  
 room fires; wall coverings; building materials; fire tests; flame attachment; heat flux; ignition; *NBSIR 82-2503*.  
 room fire tests; burning rate; compartment fires; flammability regulations; flashover; furniture flammability; *21089*.  
 room fire tests; smoke density chamber; smoke measurement; furnishings; furniture; mattress flammability; *21095*.  
 room return; air scatter; calibration; californium; dose equivalent; dosimeter; neutron; remmeter; *SP633*.  
 room temperature; thermal response factors; thermostat control; burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; residential furnaces; *20903*.  
 Rosenbluth separation; 10.3 MeV transition;  $^{40}\text{Ca}$ ; form factor; ground state transition width; inelastic electron scattering; magnetic dipole; *21037*.  
 rotating disk; roughness; ships; stylus; surface roughness; surface topography; disks; drag; flow; friction disk; hulls; hydrodynamic drag; *TN1151*.  
 rotational constants; band centers; carbonyl sulfide; diode laser spectra; heterodyne frequency measurements; infrared spectroscopy; *20852*.  
 rotational isomeric state model; switchboard model; gambler's ruin problem; Monte Carlo; polyethylene; polymer; polymer between two plates; *21138*.  
 rotational levels; Zeeman effect; CH; far infrared; hyperfine constants; lambda doubling; laser magnetic resonance; *21273*.  
 rotational line strengths; transition moments; diatomic molecules; intensity factor; notation conventions; *21274*.  
 rotational spectra; ultraviolet; vibrational spectra; visible; electronic spectra; infrared; microwave; molecular spectroscopy; *21388*.  
 rotational spectrum; ethanol; intensities; interstellar molecules; microwave spectra; molecular constants; propionitrile; radio astronomy; *JPCRD 11(2)*: 251-312; 1982.  
 rotational spectrum; structure; borane monoammoniate; electric dipole moment; microwave spectrum; molecular structure; *21337*.  
 rotational transitions; absorption coefficients; carbonyl sulphide; intensities; microwave transitions; *JPCRD 11(1)*: 101-117; 1982.  
 rotational transitions; spectra; absorption coefficient; collision-induced; far infrared spectra; hydrogen; hydrogen mixtures; *21165*.

roughness; ships; stylus; surface roughness; surface topography; disks; drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; *TN1151*.  
 round robin; surface analysis; Auger-electron spectroscopy; *20927*.  
 rovibronic species; statistical weights; symmetric top molecules; group theory; nuclear spin; *21300*.  
 Royal Observatory; time ball; time signals; chronometers; Greenwich; *21024*.  
 RS Canum Venaticorum binaries; spectrophotometry; stars, individual; symbiotic stars; mass exchange; *20808*.  
 RTV; silicone; encapsulant; integrated circuit; *SP400-72*; 1982 April. 275-280.  
 rubber; textiles; directory; ferrous metals; glass; nonferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; *NBS-GCR-82-366*.  
 rubber hose; solar energy systems; glycol antifreeze stability; heat transfer liquid; hose; hose immersion test; hose specification; *NBSIR 81-2352*.  
 rubidium; anharmonic effects; Debye-Waller factor; lattice dynamics; lithium; molecular dynamics; *21096*.  
 rubidium beam; rubidium cell; rubidium frequency standard; atomic frequency standard; laser frequency standard; optical pumping; *21203*.  
 rubidium cell; rubidium frequency standard; atomic frequency standard; laser frequency standard; optical pumping; rubidium beam; *21203*.  
 rubidium frequency standard; atomic frequency standard; laser frequency standard; optical pumping; rubidium beam; rubidium cell; *21203*.  
 rural areas; water conservation; agricultural water uses; demand reduction; drought emergency plans; educational programs; *SP624*; 1982 June. 465-469.  
 rural fires; fire cause; fire data; fire fatalities; fire statistics; heating equipment; residential fires; *NBSIR 82-2519*.  
 rust prevention; vehicular rust; battery-acid corrosion; metal coating; polymer coating; *SP640*; 1982 October. 275-289.  
 Rydberg series; angular distributions;  $c^4\sum_u$  limit; electrons; experimental; inelastic scattering;  $\text{O}_2$ ; *21077*.  
 Rydberg state; autoionizing resonances; photoelectron angular distributions; photon energy; *20870*.

## S

safety; sensors; ultrasonic; echo-ranging transducer; industrial robots; robots; *20977*.  
 safety; shear properties; splitting tensile strength; statistical analysis; age-strength relation; building codes; compressive strength; concretes; regression analysis; *21150*.  
 safety; signs; standards; symbols; visual alerting; warning; communication; design issues; hazard; pictograms; pictorial; *BSS141*.  
 safety; standards; bioeffects; dosimetry; electromagnetic; exposure; nonionizing; radiation; radiofrequency; regulation; *21038*.  
 safety; vehicle inspections; highway transportation; *SP621*; 1982 October. 177-185.  
 safety equivalency; safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; *NBSIR 82-2562*.  
 safety evaluation; smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; *NBSIR 82-2562*.  
 safety-related defects; safety standards; auto safety hotline; defects; motor vehicle equipment; motor vehicles; NHTSA; *SP621*; 1982 October. 212-214.  
 safety standards; auto safety hotline; defects; motor vehicle equipment; motor vehicles; NHTSA; safety-related defects; *SP621*; 1982 October. 212-214.  
 salt fog; alternate immersion; corrosivity monitoring device; exposure tests; marine environments; *SP640*; 1982 October. 476-494.  
 salts; croconates; dicyanomethylene; electrochemical; electron-transfer; mechanism; oxidation; reversible; *21103*.  
 salt spray corrosion resistance; warded lock; ace type pin tumbler lock; cheek plate tamper resistance; *21199*.  
 salt-spray test; short-term tests; coatings; *21060*.  
 samarium; spectrum; tantalum; tungsten; ytterbium; barium;



dysprosium; energy levels; erbium; gadolinium; neodymium; 20845.  
sample characterization; sample variability; calorific value; flow calorimetry; kilogram-size samples; municipal solid waste; refuse-derived fuel; *NBSIR 82-2491*.  
sample dryer; thermal ionization mass spectrometry; isotopic analysis; isotopic fractionation; *TN1154*.  
sample handling; sample storage; sampling; trace element analysis; analytical blank; contamination control; 21373.  
sample preparation; asbestos identification; asbestos standard; electron microscopy; fiber counts; *SP619*; 1982 March. 138-144.  
samplers; soil tests; standard penetration tests; drills; in situ test; penetration tests; practice; 20867.  
sample storage; sampling; trace element analysis; analytical blank; contamination control; sample handling; 21373.  
sample variability; calorific value; flow calorimetry; kilogram-size samples; municipal solid waste; refuse-derived fuel; sample characterization; *NBSIR 82-2491*.  
sampling; sampling atmospheres; sampling food; sampling miscellaneous materials; sampling plan; sampling water; chemical analysis; *TN1153*.  
sampling; signal period; algorithm; converter; distortion; microcomputer; rms value; *TN1159*.  
sampling; trace element analysis; analytical blank; contamination control; sample handling; sample storage; 21373.  
sampling atmospheres; sampling food; sampling miscellaneous materials; sampling plan; sampling water; chemical analysis; sampling; *TN1153*.  
sampling errors; ambient air; asbestos; EPA provisional method; fibers; *SP619*; 1982 March. 154-161.  
sampling food; sampling miscellaneous materials; sampling plan; sampling water; chemical analysis; sampling; sampling atmospheres; *TN1153*.  
sampling miscellaneous materials; sampling plan; sampling water; chemical analysis; sampling; sampling atmospheres; sampling food; *TN1153*.  
sampling plan; sampling water; chemical analysis; sampling; sampling atmospheres; sampling food; sampling miscellaneous materials; *TN1153*.  
sampling-rate drift; deconvolution; digital sampling; fast Fourier transforms; *SP634*; 1982 June. 47-53.  
sampling water; chemical analysis; sampling; sampling atmospheres; sampling food; sampling miscellaneous materials; sampling plan; *TN1153*.  
sand; sea bed; stress; time dependent; unsteady; water tunnel; waves; drag; oscillatory flow; phase dependent; ripple; 21332.  
sand; seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; *BSS138*.  
sand; shear test; simple shear test; size effects; cyclic loading; dynamic test; laboratory test; 20857.  
Sandia Particle Beam Fusion Accelerator; SuperMite; CAMAC pulse processing modules; inertial confinement fusion; *SP628*; 1982 June. 325-340.  
sandwich structure; testing; composite materials; laminate structure; maintenance; repairability; *SP640*; 1982 October. 364-378.  
sanitary performance; surface cleansing; test methods; volumetric efficiency; waste removal; water closets; residential water use; *SP624*; 1982 June. 273-280.  
SANS; semicrystalline polymer; adjacent reentry; fold plane roughening; melt crystallization; polyethylene; polyethylene fold planes; polymer; polymer crystallization; 21160.  
satellite; shuttle time; time and frequency metrology; time comparisons; Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; 21201.  
satellite clocks; SI second; synchronization; syntonization; time scales; coordinate time; frequency standards; international atomic time; relativity; 21188.  
satellite theory; algebra by computer; Birkhoff normalisation; celestial mechanics; resonances; 20777.  
satellite theory; celestial mechanics; Fourier series; lunar theory; 21030.  
saturated liquid; specific heat; thermodynamic properties; coexistence; ethylene; heat capacity; 21187.  
saturation density; vapor phase; virial coefficients; Burnett method; equation of state; ethylene; helium; 21228.  
saturation spectrum; atomic mercury; degenerate four-wave mixing; excited state spectrum; 20983.  
scale models; fire growth; flashover; heat release rate; physical modeling; room fires; *NBSIR 81-2453*.  
scales; specifications; taximeters; tolerances; user requirements; volume-measuring devices; weights; length-measuring devices; liquid-measuring devices; measures; *H44*.  
scaling; Fermion masses; internal spaces; mixing angles; neutrino oscillations; potentials; 21168.  
scandium alloys; spin glass; antiferromagnetism; critical fields; ferromagnetism; rare earths; 21129.  
scanning acoustic microscope; semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; *NBS-GCR-80-204*.  
scanning acoustic microscopy; semiconductor devices and integrated circuit inspection; acoustic material signatures; acoustic microscopy; *NBS-GCR-81-363*.  
scanning acoustic microscopy; semiconductor devices and integrated circuit inspection; acoustic material signatures; acoustic microscopy; *NBS-GCR-82-401*.  
scanning electron microscopy; secondary electron emission; spin analyzer; spin polarized secondary electron; electron spin polarization; ferromagnetic glass; 21360.  
scanning transmission; selected area electron diffraction; transmission electron microscope; electron microscope; energy dispersive x-ray spectrometry; image analysis; *SP619*; 1982 March. 207-210.  
scattered neutrons; background; calibration; californium neutrons; personnel monitoring; reflected neutrons; 20966.  
scattering; autoionization; collisions; dielectronic recombination; multicharged ions; 20880.  
scattering; ultrasonic waves; variational method; acoustic waves; cracks; finite element method; nondestructive evaluation; 21229.  
scattering; variational method; elastic waves; flaws; nondestructive evaluation; nondestructive testing; 21239.  
scattering matrix; thin film; transmittance extrema; electro-optic modulation; hydrogenated amorphous silicon; optical transmittance; refractive index; *NBSIR 81-1652*.  
scenario; alcohol; carbon monoxide; cigarettes; fatalities; fire; heart disease; heavy metals; hydrogen chloride; 20858.  
scenario; smoldering; cigarettes; codes; escape; fatalities; fire; flaming; flashover; nonresidential; residential; 20775.  
scene analysis; vision; vision systems; artificial intelligence; automation; computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; *NBSIR 82-2582*.  
schema; standards; system architecture; system components; database; database function; database management system; data model; *SP500-86*.  
schema design; database design; database design tools; database management; logical database design; logical database design tools; *NBS-GCR-82-389*.  
schema design; database design; database management; database modeling; database schema translation; database semantics; entity-relationship model; hierarchical data model; logical database design; network data model; relational data model; *NBS-GCR-82-390*.  
Schottky barrier diodes; SIMS and C-V profile comparisons; automatic C-V profiler analyses; carrier depth distributions; differential capacitance-voltage profiling; ion implantation; ranges of application and limitations; *SP400-71*.  
science; software edge; fundamental research; Government-industry relationships; industrial technology; NBS 80th Anniversary; productivity; *SP627*.  
scientific workload; vector processing; Amdahl's Law; benchmarking; computing environment; large-scale scientific computing; parallel processing; *SP500-95*; 1982 October. 121-126.  
Sc XVI; Ti XVII; wavelengths; V XVIII; Ca XV; Cl XII; energy levels; K XIV; 21393.  
sea bed; stress; time dependent; unsteady; water tunnel; waves; drag; oscillatory flow; phase dependent; ripple; sand; 21332.  
sealing glass; Cerdip; integrated circuit packaging; internal water vapor; moisture evolution; package reliability; *SP400-72*; 1982 April. 220-233.  
seam sealing; sensor chips; standards; water vapor; dew point; hermetic packages; mass spectrometer; *SP400-72*; 1982 April. 49-63.  
seasonal cost of operation; test method; central air conditioners; heat pumps; rating procedure; *NBSIR 81-2434*.  
secondary electron emission; spin analyzer; spin polarized secondary



- electron; electron spin polarization; ferromagnetic glass; scanning electron microscopy; *21360*.
- secondary-ion mass spectroscopy; surface analysis; x-ray photoelectron spectroscopy; Auger-electron spectroscopy; ESCA (electron spectroscopy for surface analysis); ion-scattering spectroscopy; *21382*.
- secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; *21254*.
- secondary ozonide; thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; *21255*.
- secondary standard laboratory; traceability; calibrations; ionizing radiation; measurements; national standards; quality assurance; *SP609*.
- second harmonic generation; self pulsing; subharmonic generation; dispersive bistability; fluctuations; nonequilibrium phase transitions; nonlinear optics; optical bistability; *20918*.
- second sound; shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; *20836*.
- second surface mirrors; solar reflectance; specular spectral reflectance; aluminum mirrors; directional specular reflectance; reflectance specular; reflectance standards; *SP260-79*.
- second virial coefficients; vapor-liquid equilibrium; vapor pressure; volume change of mixing; equations of state; heat of mixing; liquid density; mixtures; *JPCRD 11(3): 941-951; 1982*.
- segmentation; system parameters; transportable computer software; ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; *TN1163*.
- segregation; specific heat; surface tension; thermophysical properties; tungsten; Auger spectroscopy; convection; gallium-tin alloys; levitation calorimetry; *NBSIR 82-2560*.
- seismic loading; shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; *BSS138*.
- selected area electron diffraction; transmission electron microscope; electron microscope; energy dispersive x-ray spectrometry; image analysis; scanning transmission; *SP619; 1982 March. 207-210*.
- selected ordinate; solar absorber materials; solar cover plates; transmittance; weighted ordinate; air mass; ASTM E 424; integrating sphere spectrophotometer; reflectance; *NBSIR 81-2448*.
- selection criteria; software standards; Advanced Computer System; *SP500-94; 1982 October. 36-39*.
- selective signaling; squelch systems; tone-coding; decoder; digital controlled; encoder; law enforcement standard; *20991*.
- self-consistent field theory; ab initio; electronic structure; multiconfiguration; photodissociation; *21308*.
- self-diffusion coefficients; diffusion; diffusion coefficients; diffusion techniques; fused salts; molten salts; *JPCRD 11(3): 505-693; 1982*.
- self documenting; English-like; programming language; *SP500-94; 1982 October. 84-94*.
- self-extinguishment; smoldering; test development; textiles; upholstered furniture; cigarettes; fabrics; flammability; ignition; polyester batting; polyurethane foam; *21128*.
- self pulsing; subharmonic generation; dispersive bistability; fluctuations; nonequilibrium phase transitions; nonlinear optics; optical bistability; second harmonic generation; *20918*.
- self-tuning control algorithm; adaptive control; air handling unit; direct digital control; energy management and control systems; HVAC system control; parameter estimator; PI-controller; recursive least squares algorithm; *NBSIR 82-2591*.
- semantic integrity; constraint; database; database management system; data correctness; integrity; networks; remote access of data; *21124*.
- SEM fractography; cast steels; fatigue crack growth rates; fracture analysis; mechanical testing; microstructure; rail vehicles; *SP621; 1982 October. 33-45*.
- semiconducting diamond; surface reconstruction; surface states; vibrational spectra; deuterium on diamond; diamond(111) 1×1; EELS; electron energy loss spectroscopy; hydrogen on diamond; *21288*.
- semiconduction; conductivity; croconates; crystallographic; electrical; electrochemical; mechanism;  $\pi$ -acceptors; *J. Res. 87(3): 257-260; 1982 May-June*.
- semiconductor devices; analysis of moisture content; hermetically packaged semiconductor devices; mass spectrometer measurement; moisture; moisture generators; moisture sensors; quality control; reliability of semiconductor devices; *SP400-72*.
- semiconductor devices; dew point; failure; hybrid microcircuit; moisture; nichrome resistors; *SP400-72; 1982 April. 175-177*.
- semiconductor devices; VDMOS; drain-source resistance; electron devices; gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; power transistors; radiation effects; *21000*.
- semiconductor devices and integrated circuit inspection; acoustic material signatures; acoustic microscopy; scanning acoustic microscopy; *NBS-GCR-81-363*.
- semiconductor devices and integrated circuit inspection; acoustic material signatures; acoustic microscopy; scanning acoustic microscopy; *NBS-GCR-82-401*.
- semiconductor materials characterization; semiconductors; thermally stimulated measurements; thermometry; deep level measurements; measurement methods; *21144*.
- semiconductors; accurate measurements; benefit-cost analysis; cost savings; economic analysis; photomask linewidth measurements; *NBSIR 82-2458*.
- semiconductors; silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; *NBS-GCR-80-204*.
- semiconductors; silicon; standard reference materials; measurements; metrology; reference materials; *20829*.
- semiconductors; thermally stimulated measurements; thermometry; deep level measurements; measurement methods; semiconductor materials characterization; *21144*.
- semiconductor technology; statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; *SP400-74*.
- semicrystalline polymer; adjacent reentry; fold plane roughening; melt crystallization; polyethylene; polyethylene fold planes; polymer; polymer crystallization; SANS; *21160*.
- semicrystalline polymer; small angle neutron scattering; switchboard model of polymer surface; adjacent reentry model of crystal and amorphous phase in polymer; polymer; *21161*.
- semicrystalline polymer; tie molecules; amorphous phase; crystal-amorphous interface; fold surface; loops; polymer; *21159*.
- semi-synthetic proteins; x-ray methods; active site; hydrogen bonds; protein structure; ribonuclease-S; *20914*.
- sensitivity; slotted aloha; throughput; transition matrix; carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; *SP500-95; 1982 October. 365-373*.
- sensitivity analysis; cost estimation; data collection; economic analysis; energy models; estimation; exploration; finding rates; forecasting; gas supply models; investment strategies; oil supply models; resource appraisal; *SP631*.
- sensor; solar test building; cross-section; description; passive; physical; property; *NBS-GCR-82-398*.
- sensor chips; standards; water vapor; dew point; hermetic packages; mass spectrometer; seam sealing; *SP400-72; 1982 April. 49-63*.
- sensors; ultrasonic; echo-ranging transducer; industrial robots; robots; safety; *20977*.
- separation; chemical engineering; facilitated transport; liquid membrane; membrane; purification; *21241*.
- serial; broadcast; coaxial; communication; contention; data; digital; Ethernet; local; microprocessor; network; *20839*.
- serials; standards; transactions; annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; *NBSIR 82-2575*.
- series/1; sidestreaming; simulated commands; 327X emulator; accurate data; end user; host independent; monitor; network; performance; remote; response time; *SP500-95; 1982 October. 401-407*.
- serum sodium analysis statistics; flame atomic emission spectrometry; interlaboratory performance; reference method; *21206*.
- service levels; SMF exits; workload scheduling; batch; DSNAME ENQUEUE conflict management; MVS SRM; resource-sensitive job scheduling; *SP500-95; 1982 October. 297-311*.



service levels; user service reporting system (USRS); ADP effectiveness; computer performance evaluation (CPE); computer performance management (CPM); *NBS-GCR-82-382*.

service life; wood; durability; duration of load; life data; life distribution; reliability; 20809.

service life prediction; crystal growth; encapsulants; failure mechanisms; nucleating agent; phase change storage; *NBSIR 81-2422*.

servo; sidelobe atomic peak; atomic clock; atomic resonance frequency error; fixed offset frequency; main atomic peak; microwave power level changes; *U.S. Patent 4,331,933*.

set-theoretic; database management systems; data models; DBMS simulation; positional set notation; 21270.

settling time; step response; analog-to-digital converters; code transition levels; converter testing; dynamic testing; high resolution; 20908.

SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; *NBSIR 82-2501*.

SF<sub>6</sub>; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; *NBSIR 82-2528*.

SF<sub>6</sub>; space charge; transformer oil; cables; dc fields; high voltage; incipient fault; insulation; *NBSIR 82-2586*.

SF<sub>6</sub>; streamer pulses; sulfurhexafluoride; water vapor; corona discharges; electron avalanches; gas chromatograph; mass spectrometer; 21379.

shading algorithms; solar access; solar radiation data; urban solar application; daylighting; glazing transmission; *NBSIR 82-2498*.

shale oil; speciation; arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; 21125.

shale oil analysis; solvent refined coal; determination of benzo[a]pyrene; multidimensional chromatographic analysis; on-line sequential liquid chromatographic analysis; polynuclear aromatic hydrocarbons; 20981.

shape resonance; synchrotron radiation; autoionization; photoelectron spectroscopy; 21357.

shared contingency facility; backup operations; contingency planning; disaster recovery; empty shell; reciprocal aid; recovery center; redundant facilities; *SP500-95*; 1982 October. 439-441.

shared device; computer architecture; performance evaluation; performance modeling; queueing models; queueing networks; 20802.

shear; soft sphere fluid; viscosity; computer simulation; fluid structure; nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; radial distribution function; 21237.

shear; strength; building; collapse; concrete; concrete strength; construction; failure; flat plate; *BSS145*.

shear modulus; shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; *BSS138*.

shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; low-temperature; magnetic transition; physical properties; Poisson's ratio; 21198.

shear modulus; sound velocity; ultrasonic wave; Young's modulus; boron-aluminum; elastic constants; glass-epoxy; graphite-epoxy; internal friction; 20868.

shear properties; splitting tensile strength; statistical analysis; age-strength relation; building codes; compressive strength; concretes; regression analysis; safety; 21150.

shear strain; site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; *BSS138*.

shear test; simple shear test; size effects; cyclic loading; dynamic test; laboratory test; sand; 20857.

sheet resistance; spreading resistance; multilayer Laplace equation; probe spacing; 20984.

sheet resistance; test structure; cross-bridge structure; linewidth; microelectronic test structure; process control; *NBSIR 82-2548*.

shell; collapse; concrete; concrete strength; construction; cooling tower; failure; hyperbolic shell; *BSS148*.

ships; stylus; surface roughness; surface topography; disks; drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; *TN1151*.

shock wave profile; structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; 20836.

shock waves; breakdown; dielectrics; high voltage; insulation; liquids; 21352.

short-term tests; coatings; salt-spray test; 21060.

Shuttle Mission Simulator; UNIVAC; disk I/O; hardware monitoring; performance measurement; *SP500-95*; 1982 October. 217-230.

shuttle time; time and frequency metrology; time comparisons; Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; satellite; 21201.

Si-Al-O-N; singular integral equation; crack growth model; creep cavitation; diffusive crack growth; energy release rate; high temperature fracture; *J*-integral; 20931.

sidelobe atomic peak; atomic clock; atomic resonance frequency error; fixed offset frequency; main atomic peak; microwave power level changes; servo; *U.S. Patent 4,331,933*.

sidestreaming; simulated commands; 327X emulator; accurate data; end user; host independent; monitor; network; performance; remote; response time; series/1; *SP500-95*; 1982 October. 401-407.

sidewall sprinkler systems; thermal response; automatic sprinklers; compartment fires; fire safety; life safety; room fires; *NBSIR 82-2521*.

SiF<sub>4</sub> spectra; CO<sub>2</sub> saturation spectra; diode laser spectra; heterodyne spectroscopy; isotope enrichment isotope separation; 21216.

signal period; algorithm; converter; distortion; microcomputer; rms value; sampling; *TN1159*.

signal processing; solidification; ultrasonics; interface; measurement; melting; metals; process control; pulse-echo technique; 21362.

signal sampling; stability; waveform synthesis; ac-dc difference; data conversion; dynamic response; linearity; metrology support; phase angle calibration; 21027.

signal-to-noise ratio; time domain; transient recorder; analog-to-digital converter; digitizer; dynamic testing; effective number of bits; frequency domain; quantizing error; *SP634*; 1982 June. 7-21.

signal transmission; system fault isolation; thytrons; current measurements; pulse power system; *SP628*; 1982 June. 248-255.

significant differences; statistical analysis; comparison of models; linear regression; neutron diffraction; powder refinement; 21401.

significant figures; systematic uncertainty; units; data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; 20888.

signs; standards; symbols; visual alerting; warning; communication; design issues; hazard; pictograms; pictorial; safety; *BSS141*.

silica gel; silver; silver iodide; absolute ratios; atomic weight; Faraday constant; isotopic abundance; mass spectrometry; *J. Res. 87(1)*: 9-19; 1982 January-February.

silicon; acoustic lens; acoustic microscope; acoustic transducers; acoustic wave propagation; angular spectrum; imaging contrast; materials signatures; microscopy; microwave acoustics; nondestructive testing; reflection imaging; scanning acoustic microscope; semiconductors; *NBS-GCR-80-204*.

silicon; anisotropic Yukawa potential; finite element; germanium; heavily doped semiconductors; impurity levels; 20830.

silicon; bound exciton; density of states; indium doped silicon; isoelectronic; optical properties; photoluminescence; 21146.

silicon; deep-level transient spectroscopy (DLTS); defect levels; dopant profiles; furnace anneal; ion implant; *NBS-GCR-81-364*.

silicon; finite element; heavily doped semiconductors; impurity levels; 20851.

silicon; silicon dioxide; boron; dopant profile control; ion channeling; ion implantation; 20824.

silicon; spectra; thermal annealing; annealing; boron; ion implantation; laser annealing; local mode; optical spectra; phonons; Raman spectra; 21091.

silicon; standard reference materials; measurements; metrology; reference materials; semiconductors; 20829.

silicon; sulfur; chemical interactions; deep-level measurements; defects; optical properties; 20842.

silicon; techniques, spectroscopic; FT-IR; infrared; interferograms, tertiary; methods, analytic; 20828.

silicon; valence states; Yukawa potential; bandgap narrowing; Bargmann potential; conduction states; donors; effective mass; energy dispersion; impurities; 20855.

silicon; Yukawa potential; bandgap narrowing; band states; donor impurities; Germi energy; 20921.



silicon dioxide; boron; dopant profile control; ion channeling; ion implantation; silicon; 20824.

silicon dioxide films; silicon nitride films; standard reference materials; thin films; ellipsometry; polysilicon films; 21107.

silicone; encapsulant; integrated circuit; RTV; *SP400-72*; 1982 April. 275-280.

silicone brake fluid; U.S. Army; long life; reduced maintenance; *SP640*; 1982 October. 162-169.

silicone coating; UV light; hermeticity; hybrid; leak test; methanol; *SP400-72*; 1982 April. 271-274.

silicon MOSFETs; two-dimensional electron gas; fine-structure constant; Hall effect; Landau levels; resistance standard; 21220.

silicon nitride; structural ceramics; deformation maps; high temperatures; proof testing; reliability; *NBSIR 81-2445*.

silicon nitride films; standard reference materials; thin films; ellipsometry; polysilicon films; silicon dioxide films; 21107.

silicon on sapphire; test chip; test pattern; test structure; yield; integrated circuits; microelectronics; process control; process validation wafer; *NBSIR 82-2514*.

silicon photodiode; spectral response; collection efficiency; quantum efficiency; quantum yield; 21396.

silicon photodiode; specular reflectance; ultraviolet reflectance; absorption coefficient; black paint; deuterium lamp; 20989.

silver; silver coulometer; atomic weight; atomic weight of silver; coulometer; electrochemical equivalent; Faraday constant; fundamental constants; *J. Res. 87(1)*: 21-22; 1982 January-February.

silver; silver iodide; absolute ratios; atomic weight; Faraday constant; isotopic abundance; mass spectrometry; silica gel; *J. Res. 87(1)*: 9-19; 1982 January-February.

silver; single crystal; thin films; aluminium; clusters; copper; gold; 21012.

silver coulometer; atomic weight; atomic weight of silver; coulometer; electrochemical equivalent; Faraday constant; fundamental constants; silver; *J. Res. 87(1)*: 21-22; 1982 January-February.

silver electrode; surface-enhanced Raman spectroscopy; adsorption; electrode processes; N-methylpyridinium iodide; pyridine derivatives; Raman spectroscopy; 21262.

silver iodide; absolute ratios; atomic weight; Faraday constant; isotopic abundance; mass spectrometry; silica gel; silver; *J. Res. 87(1)*: 9-19; 1982 January-February.

similarities; Stark broadening; isolated lines; neutral and ionic spectra; regularities; 21365.

similarity; term relations; automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; 21250.

simple beam theory; transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; 21175.

simple shear test; size effects; cyclic loading; dynamic test; laboratory test; sand; shear test; 20857.

simplified calculation; air conditioner; energy analysis; equipment performance; gas furnace; heat pump; 21141.

SIMS and C-V profile comparisons; automatic C-V profiler analyses; carrier depth distributions; differential capacitance-voltage profiling; ion implantation; ranges of application and limitations; Schottky barrier diodes; *SP400-71*.

simulated commands; 327X emulator; accurate data; end user; host independent; monitor; network; performance; remote; response time; series/1; sidestreaming; *SP500-95*; 1982 October. 401-407.

simulated hail testing; solar collector covers; test method development; hail damage; hail impact testing; hail launcher; *NBSIR 82-2487*.

simulated kickback motion; volunteer test subjects; chain saw kickback motion; displacement measurements; kickback energy; optoelectronic measurement system; *NBSIR 82-2559*.

simulated service test solar collector; corrosion; elevated temperature; heat transfer liquid degradation kinetics; *NBSIR 81-2339*.

simulated stagnation exposure; solar energy; absorptive coatings; accelerated laboratory exposures; degradation; outdoor exposures; *NBSIR 82-2583*.

simulation; automated manufacturing; automatic control; computer-aided design; computer-aided manufacturing; hierarchical control systems; *NBS-GCR-82-413*.

simulation; software package; systems performance; approximation techniques; queuing models; *SP500-95*; 1982 October. 139-154.

simulation; supercomputers; workload characterization; benchmarking; capacity planning; chargeback systems; computer performance management systems; queueing models; resource measurement facilities; *SP500-95*.

simulation; trunk; WIN; analytical; capacity planning; central server; disk; main memory contention; modeling; packet switch; performance evaluation; *SP500-95*; 1982 October. 97-106.

simulation; UNIVAC systems; modeling; performance evaluation; *SP500-95*; 1982 October. 231-257.

simulation; waiting time; capacity; dam; lock; queue; *NBSIR 81-2411*.

Simulation Cost Model; track maintenance planning; track standards; computer simulation; life cycle costs; maintenance, track; *SP640*; 1982 October. 199-215.

simulation of human behavior; building codes; building fires; computer-aided design; computer simulation; emergency egress; fire research; human performance; modeling; pedestrian movement; regulatory process; 20911.

sinewave; waveform digitizers; data reduction; *SP634*; 1982 June. 23-25.

sine-wave testing; transient digitizer; transient response; waveform recorder; analog-to-digital converter; digital processing; dynamic testing; *SP634*; 1982 June. 27-34.

single crystal; thin films; aluminium; clusters; copper; gold; silver; 21012.

single crystals; x rays; joint refinement; macromolecular structures; neutron; restrained refinement; 21136.

single crystal x-ray diffraction; tridentate ligand; azometalloycycle; benzotriazoleanion; copper complex; corrosion inhibitor; crystal structure; 21297.

single crystal x-ray diffraction; xanthomegnin; absolute configuration; crystal structure; dimer; fungal pigment; metabolite of pathogenic fungi; 21313.

single frequency dye laser; tuneable laser; frequency scanned laser; rapid frequency scanning; ring dye laser; 20791.

single-pan balance; analytical balance; balance dynamics; balance sensitivity; balance suspension; knife-edge bearings; Mathieu's equation; *J. Res. 87(1)*: 23-45; 1982 January-February.

single-ply roofing; tensile strength; test methods; elongation; exposure conditions; membrane properties; roofing membranes; 20841.

singular integral equation; crack growth model; creep cavitation; diffusive crack growth; energy release rate; high temperature fracture; J-integral; Si-Al-O-N; 20931.

singularity; x-ray edge; dispersion relation; perturbation theory; 20960.

SI second; automatic time comparison; deep space network; differential time transfer; frequency transfer; Global Positioning System; international time comparison; primary frequency standards; 21204.

SI second; synchronization; syntonization; time scales; coordinate time; frequency standards; international atomic time; relativity; satellite clocks; 21188.

site stability; cyclic strain; damping ratio; earthquake engineering; laboratory testing; liquefaction; particulate mechanics; particulate model; pore water pressure; sand; seismic loading; shear modulus; shear strain; *BSS138*.

size effects; cyclic loading; dynamic test; laboratory test; sand; shear test; simple shear test; 20857.

size exclusion chromatography; slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; NMR; organometallic polymers; polymers; *NBSIR 81-2424*.

size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; 20955.

Si<sup>3+</sup>; Al<sup>3+</sup>; crossed beams; cross sections; electron impact; excitation-autoionization; ionization; Mg<sup>+</sup>; Na iso-sequence; 21073.

Skill Performance Aids (SPA); Fault Detection/Location System; Failure Modes and Effects Criticality Analysis (FMECA); Reliability Centered Maintenance (RCM); caution, warning and advisory panels; Multiplex (MUX) System; fire control computer; on-condition monitor; condition monitoring; Built-in Test Equipment (BITE); *SP640*; 1982 October. 235-254.

slag vaporization; transpiration; Knudsen effusion; mass spectrometry; 21282.



slope; solid; stream-depth; surge; transport; velocity; water; equation; flow; horizontal; motion; partially-filled pipe; *NBSIR 81-2450*.

slot; aperture; cavity; equivalence principle; field distribution; *NBSIR 82-1659*.

slotted aloha; throughput; transition matrix; carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; *SP500-95*; 1982 October. 365-373.

slow-release antifoulant; tin; atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; *NBSIR 81-2424*.

Sm; Tb; wavelength; Ce; energy levels; Eu; Gd; Ho; Nd; Pr; 20877.

small angle neutron scattering; switchboard model of polymer surface; adjacent reentry model of crystal and amorphous phase in polymer; polymer; semicrystalline polymer; 21161.

small computers; software; word processing; microprocessors; personal computers; *NBSIR 82-2573*.

small particles; solid solutions; strain; surfaces; thermodynamics; coherency; composites; 20807.

small samples; density; density changes; density of solids; *J. Res. 87(3)*: 207-209; 1982 May-June.

small-scale turbulence; velocity gradients; higher-order moments; hot-wire anemometry; lognormal; 21278.

small solid objects; solid object density scale; density measurement; float method; *J. Res. 87(3)*: 197-206; 1982 May-June.

smearing; spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; *SP640*; 1982 October. 257-274.

SMF exits; workload scheduling; batch; DSNAM ENQUEUE conflict management; MVS SRM; resource-sensitive job scheduling; service levels; *SP500-95*; 1982 October. 297-311.

smoke; bibliographies; building fires; coal mines; combustion products; compartment fires; fabric flammability; fire research; fire tests; flame research; *NBSIR 82-2499*.

smoke; fire growth; fuel load; heat release rate; prison cell fire; *NBSIR 82-2469*.

smoke; smoke density chamber; optical density; test methods; visibility; correlation; fire tests; full-scale; *NBSIR 82-2508*.

smoke; smoke detection; smoke production; smoldering; aerosol coagulation; combustion aerosols; particle size distribution; 21231.

smoke; smoke movement; stack effects; test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; 21121.

smoke candle test; smoke control; stairwell pressurization; top injection; tracer gas test; bottom injection; multiple injection; 21307.

smoke chamber; tables; ASTM E162; fire tests; flame spread; plastics; *NBSIR 81-2400*.

smoke control; smoke exhaust; smoke movement; ventilation systems; ceiling systems; hazard analysis; hospitals; interstitial space; mattresses; *NBSIR 81-2444*.

smoke control; smoldering; sprinkler systems; toxicity; arson; building design; combustion products; fire investigation; fire modeling; fire protection; human behavior; *SP639*.

smoke control; stairwell pressurization; top injection; tracer gas test; bottom injection; multiple injection; smoke candle test; 21307.

smoke control; stairwells; building fires; egress; elevators; handicapped; pressurization; 21226.

smoke control; stairwells; building fires; egress; elevators (lifts); evacuation; handicapped; pressurization; *NBSIR 82-2507*.

smoke density chamber; optical density; test methods; visibility; correlation; fire tests; full-scale; smoke; *NBSIR 82-2508*.

smoke density chamber; smoke measurement; furnishings; furniture; mattress flammability; room fire tests; 21095.

smoke detection; smoke production; smoldering; aerosol coagulation; combustion aerosols; particle size distribution; smoke; 21231.

smoke detection; sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; *NBSIR 82-2562*.

smoke detectors; sprinkler systems; bibliographies; evacuation; fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; *NBSIR 81-2438*.

smoke detectors; sprinkler systems; cost benefit analysis; decision analysis; fire losses; fire safety; residential buildings; *NBSIR 82-2551*.

smoke exhaust; smoke movement; ventilation systems; ceiling systems; hazard analysis; hospitals; interstitial space; mattresses; smoke control; *NBSIR 81-2444*.

smoke measurement; stack effects; furnishings; furniture; mattress flammability; room fire tests; smoke density chamber; 21095.

smoke movement; sprinkler systems; clothing wardrobes; health care facilities; hospital mattresses; 20793.

smoke movement; test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; 21121.

smoke movement; tenability limits; combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; *NBSIR 82-2578*.

smoke movement; ventilation systems; ceiling systems; hazard analysis; hospitals; interstitial space; mattresses; smoke control; smoke exhaust; *NBSIR 81-2444*.

smoke production; smoldering; aerosol coagulation; combustion aerosols; particle size distribution; smoke; smoke detection; 21231.

smolder; thermogram; cellulose; combustion; flame; inhibition; inorganic; powder; pyrolysis; retardant; 20799.

smoldering; aerosol coagulation; combustion aerosols; particle size distribution; smoke; smoke detection; smoke production; 21231.

smoldering; building fires; carbon monoxide; compartment fires; *NBSIR 82-2556*.

smoldering; cigarettes; codes; escape; fatalities; fire; flaming; flashover; nonresidential; residential; scenario; 20775.

smoldering; fabric flammability; fire models; fire tests; home fires; hospitals; mattresses; nursing homes; room fires; *NBSIR 81-2440*.

smoldering; sprinkler systems; toxicity; arson; building design; combustion products; fire investigation; fire modeling; fire protection; human behavior; smoke control; *SP639*.

smoldering; test development; textiles; upholstered furniture; cigarettes; fabrics; flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; 21128.

smoothing; spectroscopy; splines; statistical methods; linear models; minimax; peak area; *J. Res. 87(1)*: 53-65; 1982 January-February.

sodium; line broadening; nitrogen; 20871.

sodium; transport; backscattering; experiment; forward scattering; quenching; resonance; 20953.

sodium; 2s; continuum; double electron; excitation; 21331.

sodium atom; time development; transient effects; ionisation; linear polarization; monochromatic resonance; multiphoton; perturbation theory; radiation; 21075.

sodium boron; sodium borosilicate; thermodynamics; transpiration; vaporization; boric oxide; glass; 21108.

sodium borosilicate; thermodynamics; transpiration; vaporization; boric oxide; glass; sodium boron; 21108.

sodium K absorption; heat-pipe furnace; Na vapor; 21329.

sodium utate; biominerals; calcium carbonates; calcium oxalates; calcium phosphates; calcium pyrophosphate; crystal structures; hydroxyapatite; octacalcium phosphate; 21110.

soft sphere fluid; viscosity; computer simulation; fluid structure; nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; radial distribution function; shear; 21237.

software; compatibility; guidelines; procedures; *SP500-94*; 1982 October. 80-83.

software; computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; *NBS-GCR-82-387*.

software; computer program; database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; *NBS-GCR-82-384*.

software; computer program; database; database management system; data dictionary system; data management; data standards; information resource management; interactive language; language structure; *NBS-GCR-82-385*.

software; computer program; database; database management system; data dictionary system; data management; data standards; ERA model; information resource management; *NBS-GCR-82-386*.

software; software engineering; software management; software quality; software tools; toolsmith; computer environments; *SP500-91*.

software; sorption; water; algorithms; calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; *SP400-72*; 1982 April. 3-7.

software; specifications; standards; documentation; guidelines; life-



cycle; *SP500-87*.  
 software; word processing; microprocessors; personal computers; small computers; *NBSIR 82-2573*.  
 software automation; software development; software engineering; software tools; programming aids; *SP500-88*.  
 software compatibility; user experience; documentation standards; *SP500-94*; 1982 October. 8-15.  
 software development; software engineering; software testing; software tools; programming aids; software automation; *SP500-88*.  
 software development; software engineering; software tools; static analysis; compilers; dynamic analysis; programming aids; *NBSIR 81-2423*.  
 software development; software engineering; software tools; static analysis; compilers; dynamic analysis; programming aids; *NBS-GCR-82-376*.  
 software development and maintenance; software validation; standards; verification and testing; V,V&T technique and tools; environment; *NBSIR 82-2482*.  
 software documentation; development methodology; documentation process; *SP500-94*; 1982 October. 16-22.  
 software documentation; glass-faced terminal; graphic design; *SP500-94*; 1982 October. 230-235.  
 software documentation; software standards; specifications; *SP500-94*; 1982 October. 30-35.  
 software documentation; standards; *SP500-94*; 1982 October. 274-278.  
 software documentation; standards; documentation; FIPS; guidelines; program documentation; *SP500-94*.  
 software documentation; standards; information systems; computer program abstracts; *SP500-94*; 1982 October. 197-202.  
 software documentation; systems life cycle; systems management; operation phase; *SP500-94*; 1982 October. 58-67.  
 software documentation; user's groups; verbal documentation; beginning computer users; documentation; hardware systems documentation; large computer manufacturers; microcomputers; periodical literature and documentation; *SP500-94*; 1982 October. 174-179.  
 software edge; fundamental research; Government-industry relationships; industrial technology; NBS 80th Anniversary; productivity; science; *SP627*.  
 software engineering; automated documentation; documentation standards; internal documentation; *SP500-94*; 1982 October. 119-125.  
 software engineering; automated tools; program design; program documentation; program document standardization; program testing; *SP500-94*; 1982 October. 95-109.  
 software engineering; software management; software quality; software tools; toolsmith; computer environments; software; *SP500-91*.  
 software engineering; software testing; software tools; programming aids; software automation; software development; *SP500-88*.  
 software engineering; software tools; static analysis; compilers; dynamic analysis; programming aids; software development; *NBSIR 81-2423*.  
 software engineering; software tools; static analysis; compilers; dynamic analysis; programming aids; software development; *NBS-GCR-82-376*.  
 software engineering; system decomposition; top-down; documentation; documentation standards; FADPUG; *SP500-94*; 1982 October. 166-171.  
 software lifecycle; software testing; software verification; test coverage; test data generation; validation; automated software tools; *SP500-98*.  
 software maintenance; software requirements; requirements documentation; software management; *SP500-94*; 1982 October. 265-273.  
 software maintenance; testing; traceability; visibility; product assurance; *SP500-94*; 1982 October. 23-29.  
 software management; software maintenance; software requirements; requirements documentation; *SP500-94*; 1982 October. 265-273.  
 software management; software quality; software tools; toolsmith; computer environments; software; software engineering; *SP500-91*.  
 software monitor; application of basic queueing theory; IBM's RMF; job class; mathematical modeling; performance/modeling data acquisition; *SP500-95*; 1982 October. 279-296.  
 software monitors; analytic modeling; capacity planning; computer performance; modeling; models; *SP500-95*; 1982 October. 81-84.  
 software package; systems performance; approximation techniques; queueing models; simulation; *SP500-95*; 1982 October. 139-154.  
 software packages; network model analysis; queueing network models; *SP500-95*; 1982 October. 183-187.  
 software quality; software tools; toolsmith; computer environments; software; software engineering; software management; *SP500-91*.  
 software requirements; requirements documentation; software management; software maintenance; *SP500-94*; 1982 October. 265-273.  
 software standards; Advanced Computer System; selection criteria; *SP500-94*; 1982 October. 36-39.  
 software standards; specifications; software documentation; *SP500-94*; 1982 October. 30-35.  
 software summary; ANSI Z39.2; bibliographic control; FIPS 30; format structure; machine-readable cataloging; machine-readable data files; MARC; MRDF; numeric data files; *SP500-94*; 1982 October. 189-196.  
 software systems; performance engineering techniques; *SP500-95*; 1982 October. 433.  
 software testing; software tools; programming aids; software automation; software development; software engineering; *SP500-88*.  
 software testing; software verification; static analysis; test coverage; validation; V,V&T techniques; V,V&T tools; automated software tools; dynamic analysis; formal analysis; *SP500-93*.  
 software testing; software verification; test coverage; test data generation; validation; automated software tools; software lifecycle; *SP500-98*.  
 software testing; structured testing; measures; metric; program complexity; *SP500-99*.  
 software tools; coverage analysis; dynamic analysis; performance monitoring; program analysis; program instrumentation; *SP500-95*; 1982 October. 195-202.  
 software tools; programming aids; software automation; software development; software engineering; software testing; *SP500-88*.  
 software tools; static analysis; compilers; dynamic analysis; programming aids; software development; software engineering; *NBSIR 81-2423*.  
 software tools; static analysis; compilers; dynamic analysis; programming aids; software development; software engineering; *NBS-GCR-82-376*.  
 software tools; toolsmith; computer environments; software; software engineering; software management; software quality; *SP500-91*.  
 software tuning; data tuning; modeling; MVS; performance measurement data; *SP500-95*; 1982 October. 313-320.  
 software validation; standards; verification and testing; V,V&T technique and tools; environment; software development and maintenance; *NBSIR 82-2482*.  
 software verification; static analysis; test coverage; validation; V,V&T techniques; V,V&T tools; automated software tools; dynamic analysis; formal analysis; software testing; *SP500-93*.  
 software verification; test coverage; test data generation; validation; automated software tools; software lifecycle; software testing; *SP500-98*.  
 soil anchors; soil mechanics; stiffness; wind forces; anchors; cyclic loading; field testing; flood forces; foundations; load capacity; mobile homes; *BSS142*.  
 soil mechanics; stiffness; wind forces; anchors; cyclic loading; field testing; flood forces; foundations; load capacity; mobile homes; soil anchors; *BSS142*.  
 soil moisture; soil tests; tests; thermal conductivity; thermal resistivity; Atterberg Limit tests; compaction; compaction tests; heat flow; laboratory tests; *BSS149*.  
 soils; telephone cables; underground; alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; *NBSIR 82-2509*.  
 soil tests; standard penetration tests; drills; in situ test; penetration tests; practice; samplers; *20867*.  
 soil tests; tests; thermal conductivity; thermal resistivity; Atterberg Limit tests; compaction; compaction tests; heat flow; laboratory tests; soil moisture; *BSS149*.  
 solar; calcium-aluminum hydrates; calorimetry; dehydration; energy storage; rehydration; *NBSIR 82-2531*.  
 solar; solar domestic hot water system; stratification; test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; NBS; *BSS140*.  
 solar; space-heating; air-cooling; air leakage; energy; heat-recovery; insulation; measurement; office-building; radiant; *20961*.  
 solar; standards; testing; energy; heat transfer; hot water; measurement; rating; *21264*.  
 solar; temperature; fluid flow; instrumentation; irradiance;



measurements; 21349.

solar absorber materials; solar cover plates; transmittance; weighted ordinate; air mass; ASTM E 424; integrating sphere spectrophotometer; reflectance; selected ordinate; *NBSIR 81-2448*.

solar access; solar radiation data; urban solar application; daylighting; glazing transmission; shading algorithms; *NBSIR 82-2498*.

solar collector; standards; thermal performance; uncertainty; collector rating; incident angle modifier; measurement; 21387.

solar collector covers; test method development; hail damage; hail impact testing; hail launcher; simulated hail testing; *NBSIR 82-2487*.

solar collectors; fire tests; roofing fire resistance; roofing fire tests; *NBSIR 81-2344*.

solar collectors; fire tests; roofing fire resistance; roofing fire tests; 21134.

solar collectors; solar energy; solar energy transmittance; tensile properties; weathering of cover plates; artificial weathering; cover plate materials; durability; natural weathering; *TN1170*.

solar cover plates; transmittance; weighted ordinate; air mass; ASTM E 424; integrating sphere spectrophotometer; reflectance; selected ordinate; solar absorber materials; *NBSIR 81-2448*.

solar data base; solar energy system; solar hot water, space heating and cooling; automatic data processing; computer reports; grant data; residential buildings; *NBSIR 81-2376*.

solar data base; solar energy systems; solar heating and cooling; automatic data processing; data base; residential buildings; *NBSIR 81-2369*.

solar data energy system; solar heating and cooling; automatic data processing; data dictionary/directory; residential buildings; *NBSIR 81-2357*.

solar domestic hot water; solar simulator; standard; test method; ASHRAE 95; collectors; 20940.

solar domestic hot water system; stratification; test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; NBS; solar; *BSS140*.

solar energy; absorptive coatings; accelerated laboratory exposures; degradation; outdoor exposures; simulated stagnation exposure; *NBSIR 82-2583*.

solar energy; building economics; commercial buildings; economic analysis; energy economics; life-cycle costing; *NBSIR 82-2540*.

solar energy; fading; measurement of lamp output; plastic plate; quinoline dye; 20798.

solar energy; solar energy transmittance; tensile properties; weathering of cover plates; artificial weathering; cover plate materials; durability; natural weathering; solar collectors; *TN1170*.

solar energy; standards; building; cooling; heating; hot water; performance criteria; *BSS147*.

solar energy; standards; building regulations; buildings; energy; enforcement; health and safety; passive design; *NBSIR 82-2554*.

solar energy; standards; buildings; cooling; heating; hot water; performance criteria; 21082.

solar energy; standards; test procedures; code provisions; passive solar systems; performance criteria; 21119.

solar energy; thermal performance; active solar; evaluation process; hot water; passive solar; performance criteria; *NBS-GCR-82-397*.

solar energy computer program; solar energy economics; solar energy systems; computer simulation models; Federal Life-Cycle Cost Rules; life-cycle cost analysis; net savings; *NBSIR 81-2379*.

solar energy economics; solar energy systems; computer simulation models; Federal Life-Cycle Cost Rules; life-cycle cost analysis; net savings; solar energy computer program; *NBSIR 81-2379*.

solar energy system; solar hot water, space heating and cooling; automatic data processing; computer reports; grant data; residential buildings; solar data base; *NBSIR 81-2376*.

solar energy systems; computer simulation models; Federal Life-Cycle Cost Rules; life-cycle cost analysis; net savings; solar energy computer program; solar energy economics; *NBSIR 81-2379*.

solar energy systems; glycol antifreeze stability; heat transfer liquid; hose; hose immersion test; hose specification; rubber hose; *NBSIR 81-2352*.

solar energy systems; solar heating and cooling; automatic data processing; data base; residential buildings; solar data base; *NBSIR 81-2369*.

solar energy systems; standards; durability; plastic containment materials; *NBSIR 82-2533*.

solar energy systems; standards; wind energy; biomass; heating and cooling; performance criteria; photovoltaics; 21106.

solar energy transmittance; tensile properties; weathering of cover plates; artificial weathering; cover plate materials; durability; natural weathering; solar collectors; solar energy; *TN1170*.

solar heating and cooling; automatic data processing; data base; residential buildings; solar data base; solar energy systems; *NBSIR 81-2369*.

solar heating and cooling; automatic data processing; data dictionary/directory; residential buildings; solar data energy system; *NBSIR 81-2357*.

solar hot water, space heating and cooling; automatic data processing; computer reports; grant data; residential buildings; solar data base; solar energy system; *NBSIR 81-2376*.

Solar Maximum Mission; solar transition region; steady velocity fields; Sun; 21213.

solar radiation; spectroradiometry; UV spectral measurements; atmospheric attenuation; atmospheric ozone; optical radiation measurements; radiometry; *TN910-5*.

solar radiation data; urban solar application; daylighting; glazing transmission; shading algorithms; solar access; *NBSIR 82-2498*.

solar reflectance; specular spectral reflectance; aluminum mirrors; directional specular reflectance; reflectance specular; reflectance standards; second surface mirrors; *SP260-79*.

solar simulator; standard; test method; ASHRAE 95; collectors; solar domestic hot water; 20940.

solar test building; cross-section; description; passive; physical; property; sensor; *NBS-GCR-82-398*.

solar transition region; steady velocity fields; Sun; Solar Maximum Mission; 21213.

solid; crystal structure; hydrogen; phase diagram; properties; 20979.

solid; stream-depth; surge; transport; velocity; water; equation; flow; horizontal; motion; partially-filled pipe; slope; *NBSIR 81-2450*.

solid angle; spectrometer; momentum acceptance; nucleon; pair correlation function; resolution; 21402.

solid conduction; thermal conductivity; convection; foam; gas conduction; guarded-hot-plate; insulation; low temperature; radiation; *NBSIR 82-1664*.

solid fuel; absorption; ignition; radiation; 21314.

solid fuel; Damkohler number; flame spread; gas phase; heat transfer; laminar flame; Laser Doppler Velocimeter; opposed flow; *NBS-GCR-82-388*.

solid fuels; additives; computer models; flame spread; pyrolysis; *NBS-GCR-82-396*.

solidification; ultrasonics; interface; measurement; melting; metals; process control; pulse-echo technique; signal processing; 21362.

solidification; undercooling; amorphous; cooling rate; crystalline; dendrites; interfaces; microcrystalline; nucleation; recalcence; 21090.

solid lubricant; wear; wear debris; antimony thioantimonate; electron microscopy; lubricant additive; *NBSIR 82-2545*.

solid lubricant additive; abrasive wear; antimony thioantimonate; extreme pressure and antiwear properties; greases; *SP640*; 1982 October. 150-161.

solid object density scale; density measurement; float method; small solid objects; *J. Res. 87(3)*: 197-206; 1982 May-June.

solid-solid phase boundaries; AB<sub>2</sub>-type compounds; calibration; critically evaluated data; crystallographic data; experimental melting curves; high pressure; high temperature; polymorphism; p, T phase diagrams; *JPCRD 11(4)*: 1005-1064; 1982.

solid solution; tantalum oxide; lithium tantalate; neutron diffraction; powder method; Rietveld method; 21157.

solid solutions; strain; surfaces; thermodynamics; coherency; composites; small particles; 20807.

solid state devices; transistor; electronics; noise; photon detector; rectifier; *TN1169*.

solid transport; unsteady flow; computer based model; drainage; *BSS139*.

solid waste; total energy; utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; *SP489*, Supplement 1.

solid waste management; steam production; destruct heating; electricity production; energy recovery; incineration; New York City; resource recovery; *NBS-GCR-82-409*.

soliton; doping; impurity states; midgap absorption; nonhydrogenic states; polaron; polyacetylene; 21104.

solubility; diffusion; hydrophobic; moisture permeation; polymeric materials; *SP400-72*; 1982 April. 239-245.



solubility; solutions; thermodynamics; activity coefficient; electrolyte; excess Gibbs energy; isopiestic; nickel nitrate; osmotic coefficient; 21234.

solubility; solutions; thermodynamics; activity coefficient; electrolytes; excess Gibbs energy; isopiestic; osmotic coefficient; potassium carbonate; 21233.

solubility of alloys in mercury; dental amalgam; mercury; 20850.

solubility parameters; activity coefficients; gas chromatography; octanol/water partition coefficients; *J. Res.* 87(2): 155-158; 1982 March-April.

solubilization; automotive crankcase oils; bench test procedures; catalysts; correlation; dispersancy; engine sequence tests; hot tube; laboratory bench tests; oxidation; 21279.

solution calorimetry; sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; 20930.

solutions; thermodynamic properties; activity coefficient; critical evaluation; electrolyte; excess Gibbs energy; osmotic coefficient; 20936.

solutions; thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; *NBSIR* 81-2356.

solutions; thermodynamics; activity coefficient; electrolyte; excess Gibbs energy; isopiestic; nickel nitrate; osmotic coefficient; solubility; 21234.

solutions; thermodynamics; activity coefficient; electrolytes; excess Gibbs energy; isopiestic; osmotic coefficient; potassium carbonate; solubility; 21233.

solvent contraction; solvent-water mixtures; water determination; water extraction; Karl Fischer titration; methanol-water mixtures; 21277.

solvent recovery; steel manufacturing; electroplating; Great Lakes region; hazardous waste management; paint manufacturing; resource recovery; *NBS-GCR-82-405*.

solvent refined coal; determination of benzo[a]pyrene; multidimensional chromatographic analysis; on-line sequential liquid chromatographic analysis; polynuclear aromatic hydrocarbons; shale oil analysis; 20981.

solvent-water mixtures; water determination; water extraction; Karl Fischer titration; methanol-water mixtures; solvent contraction; 21277.

soot; ion cyclotron resonance; ion-molecule; isomers; rate constants; reactivity; 21323.

soot formation; diffusion flames; flame stabilization; laser-induced fluorescence; polycyclic aromatic hydrocarbons; recirculation; 21343.

sorbate concentration; sorption; weight gain; concentration coefficient of diffusivity; density; diffusion coefficient; drawing stress; low density polyethylene; plastic deformation; 20876.

sorption; speed of sound; velocity of sound; acoustical measurements; acoustic resonator; adsorption; nitrogen; physical acoustics; preconcentration; propane; 21230.

sorption; water; algorithms; calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; software; *SP400-72*; 1982 April. 3-7.

sorption; weight gain; concentration coefficient of diffusivity; density; diffusion coefficient; drawing stress; low density polyethylene; plastic deformation; sorbate concentration; 20876.

sorption thermodynamics; absorption; adsorption; dew point; hygrometer; kinetics; microelectronic package; moisture; moisture level; relative humidity; *SP400-72*; 1982 April. 184-200.

sound velocities; specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; *TNI051*.

sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; low-temperature; magnetic transition; physical properties; Poisson's ratio; shear modulus; 21198.

sound velocity; ultrasonic wave; Young's modulus; boron-aluminum; elastic constants; glass-epoxy; graphite-epoxy; internal friction; shear modulus; 20868.

source of supply; water conservation; water use habit changes; *SP624*; 1982 June. 147-150.

sources; asbestos; asbestos analysis; asbestos standards; characterization; *SP619*; 1982 March. 5-20.

sources; standard; traceability; dosimeters; NRC; pilot study; *SP609*; 1982 February. 145-148.

South Carolina; cellulosic insulation; Florida; Georgia; newspaper recovery; North Carolina; resource recovery; *NBS-GCR-82-371*.

space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; *NBSIR* 82-2501.

space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; *NBSIR* 82-2528.

space charge; transformer oil; cables; dc fields; high voltage; incipient fault; insulation; SF<sub>6</sub>; *NBSIR* 82-2586.

space-heating; air-cooling; air leakage; energy; heat-recovery; insulation; measurement; office-building; radiant; solar; 20961.

space heating and cooling costs; space heating and cooling requirements; architecture; building design; cost-benefit analysis; economics; energy conservation; housing; insulation; *NBSIR* 81-2380.

space heating and cooling requirements; architecture; building design; cost-benefit analysis; economics; energy conservation; housing; insulation; space heating and cooling costs; *NBSIR* 81-2380.

space heating consumption; weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; *TNI156*.

spalling; corrosion; dirt; dirt and water intrusion; fine cracks; fine roughening of the surface; glazed surface; inadequate lubrication; life adjustment factor; minimum viscosity; misalignment; moisture; operating temperature; poor shaft and housing fits; smearing; *SP640*; 1982 October. 257-274.

spalling; filtration; gearboxes; helicopter transmission; pitting; rolling element bearings; rolling fatigue; *SP640*; 1982 October. 326-347.

spark; spectrum; ultraviolet; yttrium; energy level; ionization energy; 21240.

spatial economics; water conservation; water distribution systems; water supply simulation model; analytical mathematical modeling; data base management; *SP624*; 1982 June. 239-245.

spatial filter; target designators; computer simulation; laser beam profile; mode-matching analysis; *TNI057*.

specific heats; speed of sound; thermodynamic properties; vapor pressure; enthalpy; equation of state; heavy water; Helmholtz function; *PVT*; *JPCRD* 11(1): 1-14; 1982.

special relativity; surface charge conservation; transient propagation; arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; 21327.

special tests; calibration services; documentation; Measurement Assurance Programs; measurement quality control; metrology management; 20925.

speciation; arsenic; atomic absorption; environment; fingerprint; leaching; liquid chromatography; methylation; oil shale retorting; organometallics; process waters; shale oil; 21125.

speciation; triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; 21272.

specifications; software documentation; software standards; *SP500-94*; 1982 October. 30-35.

specifications; standards; documentation; guidelines; life-cycle; software; *SP500-87*.

specifications; taximeters; tolerances; user requirements; volume-measuring devices; weights; length-measuring devices; liquid-measuring devices; measures; scales; *H44*.

specifications; validation; assertions; data abstractions; implementation; *PL/I*; 20943.

specifications and tolerances; technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; *SP629*.

specific heat; speed of sound; thermodynamic properties; velocity of sound; virial coefficients; equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; 21208.

specific heat; surface tension; thermophysical properties; tungsten; Auger spectroscopy; convection; gallium-tin alloys; levitation



calorimetry; segregation; *NBSIR 82-2560*.

specific heat; thermal diffusivity; calorimetry; Fourier equation; radiative cooling; *J. Res. 87(6): 513-526; 1982 November-December.*

specific heat; thermodynamic properties; coexistence; ethylene; heat capacity; saturated liquid; *21187.*

specific heat; thermosetting polymers; varnishes; adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; *21032.*

specific heat at constant pressure; specific heat at constant volume; argon; computer programs; density; enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; *TN1048.*

specific heat at constant volume; argon; computer programs; density; enthalpy; equation of state; ethylene; hydrogen; nitrogen; nitrogen trifluoride; oxygen; specific heat at constant pressure; *TN1048.*

specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; *Monogr. 169.*

specific heats; vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; *Monogr. 170.*

specific heats; vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; *TN1051.*

specimen banking; storage evaluation and analysis; environment; human health; National Environmental Specimen Bank; *21126.*

spectra; absorption coefficient; collision-induced; far infrared spectra; hydrogen; hydrogen mixtures; rotational transitions; *21165.*

spectra; air pollution; atmospheric chemistry; chlorine monoxide; ClO; diode laser; infrared; *21303.*

spectra; spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; *21185.*

spectra; strontium; vacuum ultraviolet; yttrium; zirconium; molybdenum; niobium; *21179.*

spectra; thermal annealing; annealing; boron; ion implantation; laser annealing; local mode; optical spectra; phonons; Raman spectra; silicon; *21091.*

spectra; transient dipoles; collision-induced absorption; collision-induced light scattering; far infrared absorption; induced dipole; line shape; rare gas mixtures; *21173.*

spectra; unstable molecules; bond distance; boron chloride; diode lasers; Dunham coefficients; infrared; *20817.*

spectral behavior; absorption spectrum; atomic masses; collision-induced absorption; concentration; correlation function; density; rare gas mixtures; *21007.*

spectral line formation; stellar atmospheres; Voigt function; lineshape; radiative transfer; *21148.*

spectral moments; translational spectrum; wave mechanical lineshapes; argon; binary mixtures; collision-induced absorption; potential functions; *20929.*

spectral response; collection efficiency; quantum efficiency; quantum yield; silicon photodiode; *21396.*

spectral shape; collision-induced dipoles; collision-induced spectra; dielectric virial; intermolecular interactions; molecular constants; *21167.*

spectra series; vacuum ultraviolet; x rays; atomic spectra; atomic wavelengths; He-like ions; isoelectronic sequence; *20803.*

spectrometer; momentum acceptance; nucleon; pair correlation function; resolution; solid angle; *21402.*

spectrometer; telescope; x ray; digitizing anode; gamma ray; microchannel plate; multiple-pinhole mask; *21366.*

spectrophotometry; stars, individual; symbiotic stars; mass exchange; RS Canum Venaticorum binaries; *20808.*

spectroradiometry; UV spectral measurements; atmospheric attenuation; atmospheric ozone; optical radiation measurements; radiometry; solar radiation; *TN910-5.*

spectroscopy; absorption; high temperature; hydrogen isocyanide; infrared; molecular structure; potential functions; *20782.*

spectroscopy; appearance potential; charge transfer spectrum; electron impact ionization; ionization potential; photoelectron spectroscopy; photoionization; *NSRDS-NBS71.*

spectroscopy; asymmetry parameter; *21112.*

spectroscopy; atomic beams; cesium; frequency standards; lasers; metrology; *21252.*

spectroscopy; doublet inversions; relativistic effects; *21057.*

spectroscopy; splines; statistical methods; linear models; minimax; peak area; smoothing; *J. Res. 87(1): 53-65; 1982 January-February.*

spectroscopy; stored ion spectroscopy; atomic clock; atomic frequency standard; atomic spectroscopy; ion storage; *21285.*

spectroscopy; transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; *21185.*

spectroscopy; vibrational spectra; bond distances; carbon diselenide; infrared; molecular structure; *20801.*

spectrum; strontium; vacuum ultraviolet; yttrium; ion; laser-produced plasma; *21356.*

spectrum; tantalum; tungsten; ytterbium; barium; dysprosium; energy levels; erbium; gadolinium; neodymium; samarium; *20845.*

spectrum; ultraviolet; yttrium; energy level; ionization energy; spark; *21240.*

specular reflectance; specular standards; standard mirrors; standard reference material; absolute reflectance; aluminum mirrors; first-surface mirrors; *SP260-75.*

specular reflectance; ultraviolet reflectance; absorption coefficient; black paint; deuterium lamp; silicon photodiode; *20989.*

specular spectral reflectance; aluminum mirrors; directional specular reflectance; reflectance specular; reflectance standards; second surface mirrors; solar reflectance; *SP260-79.*

specular standards; standard mirrors; standard reference material; absolute reflectance; aluminum mirrors; first-surface mirrors; specular reflectance; *SP260-75.*

speed of sound; thermodynamic properties; vapor pressure; enthalpy; equation of state; heavy water; Helmholtz function; *PVT*; specific heats; *JPCRD 11(1): 1-14; 1982.*

speed of sound; thermodynamic properties; velocity of sound; virial coefficients; equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; *21208.*

speed of sound; velocity of sound; acoustical measurements; acoustic resonator; adsorption; nitrogen; physical acoustics; precondensation; propane; sorption; *21230.*

spin; spin-orbit interaction; surface magnetism; electron polarization; electron scattering resonances; *20891.*

spin analyzer; spin polarized secondary electron; electron spin polarization; ferromagnetic glass; scanning electron microscopy; secondary electron emission; *21360.*

spin dependent electron scattering; temperature phases; hydrogen chemisorption; PLEED; *20865.*

spin-dependent scattering; elastic scattering cross section; inelastic scattering cross section; *21101.*

spin detector; spin-orbit interaction; spin polarization; amorphous ferromagnet; exchange interaction; *21087.*

spin glass; antiferromagnetism; critical fields; ferromagnetism; rare earths; scandium alloys; *21129.*

spin-orbit coupling; *ab initio* effective spin-orbit operators; effective potentials; *21333.*

spin-orbit coupling; *ab initio* effective spin-orbit operators; effective potentials; *21338.*

spin-orbit interaction; spin polarization; amorphous ferromagnet; exchange interaction; spin detector; *21087.*

spin-orbit interaction; surface magnetism; electron polarization; electron scattering resonances; spin; *20891.*

spin-orbit splitting; surface potential barrier tungsten (100); surface resonance; electron diffraction; polarized low energy; *20976.*

spin polarization; amorphous ferromagnet; exchange interaction; spin detector; spin-orbit interaction; *21087.*

spin polarized secondary electron; electron spin polarization; ferromagnetic glass; scanning electron microscopy; secondary electron emission; spin analyzer; *21360.*

spin waves; transition metals; amorphous materials; ferromagnetism; magnetization; neutron diffraction; *20945.*

splines; approximation; clothoids; computer-aided design; Cornu spirals; curvature; curve fitting; Fresnel-integrals; interpolation; *J. Res. 87(4): 317-346; 1982 July-August.*

splines; statistical methods; linear models; minimax; peak area; smoothing; spectroscopy; *J. Res. 87(1): 53-65; 1982 January-*



February.

splitting tensile strength; statistical analysis; age-strength relation; building codes; compressive strength; concretes; regression analysis; safety; shear properties; *21150*.

sprayed insulation; asbestos; bulk material; laboratory evaluation; optical method; *SP619*; 1982 March. 44-52.

spreading resistance; contacts; gallium arsenide; potential profiling; *NBSIR 81-2403*.

spreading resistance; multilayer Laplace equation; probe spacing; sheet resistance; *20984*.

spreading resistance; thyristor; aluminum-doped silicon; dopant profiles; gallium doped silicon; resistivity profiles silicon; *21083*.

sprinkler systems; bibliographies; evacuation; fire alarm systems; fire fatalities; fires; high-rise buildings; hospitals; human behavior; nursing homes; panic; smoke detectors; *NBSIR 81-2438*.

sprinkler systems; building codes; building construction; Delphi method; fire safety; interior finishes; Life Safety Code; Minimum Property Standards; multifamily housing; risk analysis; safety equivalency; safety evaluation; smoke detection; *NBSIR 82-2562*.

sprinkler systems; clothing wardrobes; health care facilities; hospital mattresses; smoke movement; *20793*.

sprinkler systems; cost benefit analysis; decision analysis; fire losses; fire safety; residential buildings; smoke detectors; *NBSIR 82-2551*.

sprinkler systems; toxicity; arson; building design; combustion products; fire investigation; fire modeling; fire protection; human behavior; smoke control; smoldering; *SP639*.

sprinkler systems; water; corrosion; friction reduction; pipes; potable water; pressure reduction; residential buildings; *NBS-GCR-82-399*.

sputtering; surface analysis; thin films; x-ray spectroscopy; Auger spectroscopy; depth profiling; *20985*.

squelch systems; tone-coding; decoder; digital controlled; encoder; law enforcement standard; selective signaling; *20991*.

SQUIDS; superconducting fixed points; thermometry; Josephson effect; Rh-Fe; *21035*.

SRM; statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; *TN1164*.

SRM's; stability; vitamins; food matrices; methods of measurement; nutrients; *SP635*.

SRM 1470; standard reference materials; automation; computer control; gas transmission; permeation; permeation time-lag; *21026*.

stability; storage coil; superconductor; useful life; cable assembly; fatigue; *21214*.

stability; surface melting; aluminum-silver alloys; cellular growth; electron beam; interface velocity; rapid solidification; *21263*.

stability; vitamins; food matrices; methods of measurement; nutrients; SRM's; *SP635*.

stability; waveform synthesis; ac-dc difference; data conversion; dynamic response; linearity; metrology support; phase angle calibration; signal sampling; *21027*.

stability criteria; thermodynamics of the steady state; computer simulation; Couette flow; Lennard-Jones fluid; nonequilibrium molecular dynamics; nonlinear phenomena; phase changes; *20959*.

stabilized Criegee intermediate; sulfur dioxide removal; gas phase reaction; *U.S. Patent 4,351,810*.

stable isotope dilution analysis; statistical analysis; total cholesterol analysis; cholesterol analysis; definitive method; isotope dilution/mass spectrometry; mass spectrometry; *20796*.

stack effects; test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; *21121*.

stainless steel; ultrasonic scattering; ultrasonic waves; acoustic waves; elastic anisotropy; nondestructive evaluation; *21224*.

stainless steel; ultrasonic testing; elastic anisotropy; flaw detection; horizontally polarized shear waves; *21253*.

stainless steel; Young's modulus; bulk modulus; elastic constants; low-temperature; magnetic transition; physical properties; Poisson's ratio; shear modulus; sound velocity; *21198*.

stainless steels; computer-aided mechanical tests; cryogenic mechanical properties; fracture (materials); fracture toughness; J-integral; low-temperature tests; *20864*.

stairwell pressurization; top injection; tracer gas test; bottom injection; multiple injection; smoke candle test; smoke control; *21307*.

stairwells; building fires; egress; elevators; handicapped; pressurization; smoke control; *21226*.

stairwells; building fires; egress; elevators (lifts); evacuation; handicapped; pressurization; smoke control; *NBSIR 82-2507*.

standard; superconductor; critical current; critical temperature; electrical property; low-temperature; *21014*.

standard; test chip; test structure; custom; integrated circuits; multifunction; parametric tester; reliability; *20835*.

standard; testing program; conversion factors; dose equivalent; field measurement; Health Physics Society; neutrons; photons; *20813*.

standard; test method; ASHRAE 95; collectors; solar domestic hot water; solar simulator; *20940*.

standard; traceability; calibration; environment; natural material; radioactivity; radionuclide; *SP609*; 1982 February. 117-127.

standard; traceability; dosimeters; NRC; pilot study; sources; *SP609*; 1982 February. 145-148.

standard; x-ray diffraction; crystal structure; densities; lattice constants; powder patterns; reference intensities; *Monogr. 25, Section 19*.

standard antennas; antenna gain; antenna measurements; antenna pattern; antenna polarization; calibrations; near-field measurements; *21200*.

standard antennas; VHF-UHF frequency range; wavelength-size scalar horns; antenna directivity pattern; antenna measurements; calculated radiation parameters; polarization; *21222*.

standard capacitors; standard qualification; calibration; measurement assurance; reference standards; *TN1161*.

standard capacitors; standard qualification; transfer standards; calibration; measurement assurance; measurement assurance programs; reference standards; *TN1162*.

standardization; calibration; neutrons; *SP609*; 1982 February. 39-43.

standardized measurement protocol; airborne asbestos fibers; electron microscopic analysis; EPA-NBS agreement; methodology manual; *SP619*; 1982 March. 1-4.

standard mirrors; standard reference material; absolute reflectance; aluminum mirrors; first-surface mirrors; specular reflectance; specular standards; *SP260-75*.

standard packages; humidity; mass spectrometry; moisture sensors; packaging; reliability; *SP400-72*; 1982 April. 19-31.

Standard Penetration Test; boring; drilling; energy; field tests; foundation design; hammer; in-situ tests; *20951*.

standard penetration tests; drills; in situ test; penetration tests; practice; samplers; soil tests; *20867*.

standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; zinc point; aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; *SP260-77*.

standard qualification; calibration; measurement assurance; reference standards; standard capacitors; *TN1161*.

standard qualification; transfer standards; calibration; measurement assurance; measurement assurance programs; reference standards; standard capacitors; *TN1162*.

standard reference data; technical activities 1981; thermochemical and thermophysical data; data compilation; energy and environmental data; evaluated data; materials data; *NBSIR 81-2442*.

standard reference material; absolute reflectance; aluminum mirrors; first-surface mirrors; specular reflectance; specular standards; standard mirrors; *SP260-75*.

standard reference material; chemical analysis; digital periodic integrator; electron probe microanalysis; glass standards; homogeneity testing; microhomogeneity; mineral glasses; *SP260-74*.

standard reference material; synthetic sapphire; aluminum oxide; corundum; drop calorimetry; enthalpy; heat capacity; high temperature; *J. Res. 87(2): 159-163*; 1982 March-April.

standard reference material; traceability; calibration; ionizing radiation; measurement; national standards; quality assurance; *SP609*; 1982 February. 45-58.

standard reference material; x-ray fluorescence; austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; *SP260-78*.

standard reference material; x-ray fluorescence; austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; *SP260-76*.

standard reference materials; automation; computer control; gas transmission; permeation; permeation time-lag; SRM 1470; *21026*.

standard reference materials; measurements; metrology; reference materials; semiconductors; silicon; *20829*.

standard reference materials; thin films; ellipsometry; polysilicon films; silicon dioxide films; silicon nitride films; *21107*.

standard reference materials (SRM's); industrial atmosphere; lead; measurement methods; measurement systems; *SP619*; 1982 March.



- standards; ASTM E-5; fire tests; 20805.
- standards; bioeffects; dosimetry; electromagnetic; exposure; nonionizing; radiation; radiofrequency; regulation; safety; 21038.
- standards; brachytherapy; calibration; cesium-137; dosimetry standards; iodine-125; iridium-192; radium; 21311.
- standards; building; cooling; heating; hot water; performance criteria; solar energy; BSS147.
- standards; building fires; building materials; committees; fire tests; flashover; room fires; 21118.
- standards; building regulations; buildings; energy; enforcement; health and safety; passive design; solar energy; NBSIR 82-2554.
- standards; buildings; cooling; heating; hot water; performance criteria; solar energy; 21082.
- standards; calibration; differential manometer; piston gage; pressure difference; pressure transducer; TN1052.
- standards; calibration; measurement; metrology; pressure; pressure scale; 20988.
- standards; calibration; measurement; quality assurance; radon; 20834.
- standards; calibration; polarimetry; 21127.
- standards; calorimeter; cavity ionization chamber; extrapolation chamber; free-air chamber; ionizing radiation; measurement standards; radiation dosimetry; SP609; 1982 February. 29-30.
- standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cartridge; magnetic tape recordings; magnetic tape transports; FIPS PUB 93.
- standards; communications; computers; data interchange; Federal Information Processing Standard; information processing systems; magnetic tape cassettes; magnetic tape recording; magnetic tape transports; FIPS PUB 91.
- standards; composite materials; damage; fatigue; guys; mechanical testing; nondestructive testing; pultrusions; 21195.
- standards; computer networks; Federal Information Processing Standards; International Organization for Standardization; local area networks; National Bureau of Standards; network protocols; 21363.
- standards; database management; DBMS; functional specification; mandatory requirements; optional requirements; procurement; relational; NBS-GCR-82-372.
- standards; database management systems; data models; DBMS; DBMS architecture; NBS-GCR-81-340.
- standards; distributed computing; high level protocols; networking performance; network protocols; protocol standards; 21386.
- standards; documentation; FIPS; guidelines; program documentation; software documentation; SP500-94.
- standards; documentation; guidelines; life-cycle; software; specifications; SP500-87.
- standards; durability; plastic containment materials; solar energy systems; NBSIR 82-2533.
- standards; information systems; computer program abstracts; software documentation; SP500-94; 1982 October. 197-202.
- standards; software documentation; SP500-94; 1982 October. 274-278.
- standards; states; thoron; calibration; measurements; radiation; radon; radon progeny; NBS-GCR-82-394.
- standards; steel; ferrous scrap; iron; municipal solid waste; recycling; resource recovery; 21358.
- standards; stress measurement; terminology; ultrasonics; x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; residual stress; 21344.
- standards; symbols; visual alerting; warning; communication; design issues; hazard; pictograms; pictorial; safety; signs; BSS141.
- standards; system; calibration; intercomparisons; measurements; radioactivity; SP609; 1982 February. 31-37.
- standards; system architecture; system components; database; database function; database management system; data model; schema; SP500-86.
- standards; Technical Advisory Group; ASTM; building materials; fire resistance; fire tests; international; ISO; 21139.
- standards; testing; energy; heat transfer; hot water; measurement; rating; solar; 21264.
- standards; test procedures; code provisions; passive solar systems; performance criteria; solar energy; 21119.
- standards; thermal performance; uncertainty; collector rating; incident angle modifier; measurement; solar collector; 21387.
- standards; thermoluminescence; calibration; dosimetry; environmental; intercomparison; SP609; 1982 February. 111-116.
- standards; tobacco smoke; ventilation; air pollution modeling; air quality; contaminant control; 20848.
- standards; traceability; absorbed dose; environment; radioactivity; radiopharmaceuticals; 21355.
- standards; traceability; assurance; measurements; radioactivity; radiopharmaceutical; SP609; 1982 February. 99-110.
- standards; traceability; calibration; definitions; hierarchy of standards; National Bureau of Standards; radiation; SP609; 1982 February. 11-17.
- standards; traceability; calibration; measurement assurance; measurement services; SP250, 1982 Edition.
- standards; traceability; calibration instruments; calibrations; calibration techniques; SP609; 1982 February. 67-75.
- standards; traceability; calibrations; instruments; ionizing radiation; measurements; measurement support system; quality assurance; SP609; 1982 February. 3-10.
- standards; traceability; type testing; calibrations; codes of practice; ionizing radiation; regulations; SP609; 1982 February. 19-27.
- standards; traceability; x ray; calibration; instruments; measurements; SP609; 1982 February. 59-64.
- standards; traceable measurements; visual testing; acoustic emission; calibration; leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; radiography; 21398.
- standards; trace analysis; accuracy; high purity materials; instrumental neutron activation analysis; precision; reference materials; 20997.
- standards; transactions; annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; NBSIR 82-2575.
- standards; verification and testing; V,V&T technique and tools; environment; software development and maintenance; software validation; NBSIR 82-2482.
- standards; water vapor; certification; mass spectrometry; Method 1018; quantitative analysis; SP400-72; 1982 April. 32-38.
- standards; water vapor; dew point; hermetic packages; mass spectrometer; seam sealing; sensor chips; SP400-72; 1982 April. 49-63.
- standards; waveform generation; waveform measurements; waveform recorder; converters; electromagnetics; encoders; pulse; SP634.
- standards; wind energy; biomass; heating and cooling; performance criteria; photovoltaics; solar energy systems; 21106.
- standard samples; asbestos fiber; biological samples; electron microscope; fiber concentrations; SP619; 1982 March. 53-67.
- standards code; testing laboratories; accreditation; laboratory; legal system; SP632; 1982 March. 40-42.
- standards code; trade; foreign regulations; GATT; notification program; 21145.
- Stark; strong collisions; line broadening; model microfield; plasma; 20846.
- Stark broadening; Balmer lines; ion dynamics; Lyman series; plasma broadening; plasma theory; relaxation theory; 21368.
- Stark broadening; isolated lines; neutral and ionic spectra; regularities; similarities; 21365.
- Stark effect; autoionization; oscillator strength; photoionization; 21036.
- stars, accretion; stars, magnetic; stars, neutron; x rays, binaries; radiation mechanisms; 21171.
- stars, atmospheres; stars, chromospheres; stars, late-type; ultraviolet, spectra; 21070.
- stars, atmospheres; stars, circumstellar shells; stars, winds; radiative transfer; 21147.
- stars, Ba II; stars, individual; stars, late-type; stars, white dwarfs; stars, winds; ultraviolet, spectra; 20998.
- stars, binaries; stars, chromospheres; stars, individual; stars, late-type; ultraviolet, spectra; 20937.
- stars, binaries; stars, dwarf novae; stars, individual; 20963.
- stars, chromospheres; stars, individual; stars, late-type; ultraviolet, spectra; stars, binaries; 20937.
- stars, chromospheres; stars, late-type; ultraviolet, spectra; stars, atmospheres; 21070.
- stars, circumstellar shells; line formation; masers; 21033.
- stars, circumstellar shells; stars, winds; radiative transfer; stars, atmospheres; 21147.
- stars, dwarf novae; stars, individual; stars, binaries; 20963.
- stars, individual; stars, binaries; stars, dwarf novae; 20963.
- stars, individual; stars, late-type; stars, white dwarfs; stars, winds; ultraviolet, spectra; stars, Ba II; 20998.
- stars, individual; stars, late-type; ultraviolet, spectra; stars, binaries; stars, chromospheres; 20937.
- stars, individual; stellar atmospheres; stellar chromospheres;



ultraviolet spectrum; late-type stars; 20816.

stars, individual; symbiotic stars; mass exchange; RS Canum Venaticorum binaries; spectrophotometry; 20808.

stars, individual; x rays, binaries; pulsars; 21009.

stars, late-type; stars, white dwarfs; stars, winds; ultraviolet, spectra; stars, Ba II; stars, individual; 20998.

stars, late-type; ultraviolet, spectra; stars, atmospheres; stars, chromospheres; 21070.

stars, late-type; ultraviolet, spectra; stars, binaries; stars, chromospheres; stars, individual; 20937.

stars, magnetic; stars, neutron; x rays, binaries; radiation mechanisms; stars, accretion; 21171.

stars, neutron; x rays, binaries; radiation mechanisms; stars, accretion; stars, magnetic; 21171.

stars, white dwarfs; stars, winds; ultraviolet, spectra; stars, Ba II; stars, individual; stars, late-type; 20998.

stars, winds; radiative transfer; stars, atmospheres; stars, circumstellar shells; 21147.

stars, winds; ultraviolet, spectra; stars, Ba II; stars, individual; stars, late-type; stars, white dwarfs; 20998.

state; laboratory accreditation; local; NCSBCS; SP632; 1982 March. 61-62.

State and local governments; technology transfer; technology utilization; evaluation; Federal R&D; industry; innovation; 20854.

State measurement needs; test protocols; analytical procedures; hazardous waste management; lab procedures; model manual; monitoring; Resource Conservation and Recovery Act; NBS-GCR-81-355.

statement of work; acceptance tests; conversion contracting; conversion problems; deliverables; evaluation criteria; Federal agencies; language translators; portability; program inventory; RFP; SP500-90.

state-of-the-art; applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; research; NBSIR 82-2505.

state-of-the-art; applications; forecast; Japan; overview; research and development; robot; NBSIR 82-2479.

states; thoron; calibration; measurements; radiation; radon; radon progeny; standards; NBS-GCR-82-394.

static analysis; compilers; dynamic analysis; programming aids; software development; software engineering; software tools; NBSIR 81-2423.

static analysis; compilers; dynamic analysis; programming aids; software development; software engineering; software tools; NBS-GCR-82-376.

static analysis; test coverage; validation; V,V&T techniques; V,V&T tools; automated software tools; dynamic analysis; formal analysis; software testing; software verification; SP500-93.

static fatigue; strength; subcritical crack growth; cracks; fracture; glass; NBSIR 82-2524.

stationary; unshielded; chronoamperometry; coefficient; diffusion; electrodes; examination; planar; 21361.

statistical analysis; age-strength relation; building codes; compressive strength; concretes; regression analysis; safety; shear properties; splitting tensile strength; 21150.

statistical analysis; clinical analysis; glucose in serum; glucose reference method; isotope dilution/mass spectrometry; reference method; SP260-80.

statistical analysis; comparison of models; linear regression; neutron diffraction; powder refinement; significant differences; 21401.

statistical analysis; stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; 21177.

statistical analysis; total cholesterol analysis; cholesterol analysis; definitive method; isotope dilution/mass spectrometry; mass spectrometry; stable isotope dilution analysis; 20796.

statistical analysis; two-dimensional arrays; wafer map; computer program; correlation coefficient; outlier; process validation wafer; NBSIR 82-2492.

statistical analysis; workload characterization; capacity planning; job accounting; resource management; SP500-95; 1982 October. 259-273.

statistical considerations; airborne asbestos; error distributions; Gaussian assumptions; membrane filter method; SP619; 1982 March. 145-153.

statistical consulting course; statistics; training; accuracies, comparison of; government careers; in-service training; physics classroom experiments; 20947.

statistical control; statistical tests; computer software; FORTRAN; gage blocks; measurement assurance; TN1168.

statistical control of measurement process; statistical methods; tests for systematic error; uncertainty; IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; SRM; TN1164.

statistical mechanics; Kirkwood-Smoluchowski equation; liquids; nonequilibrium phenomena; nonNewtonian viscosity; 20970.

statistical methods; acceptance probability; compliance sampling; dual acceptance criteria; mixed sampling plan; order statistics; J. Res. 87(6): 485-511; 1982 November-December.

statistical methods; analysis; asbestos fibers; chrysotile filter; filter homogeneity; Poisson statistical process; SP619; 1982 March. 169-182.

statistical methods; concave; convex; inequality; majorization; median; J. Res. 87(1): 71-74; 1982 January-February.

statistical methods; linear models; minimax; peak area; smoothing; spectroscopy; splines; J. Res. 87(1): 53-65; 1982 January-February.

statistical methods; statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; SP400-74.

statistical methods; structural; errors in variable; functional; large sample, convex; regression; J. Res. 87(1): 67-70; 1982 January-February.

statistical methods; tests for systematic error; uncertainty; IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; TN1164.

statistical tests; computer software; FORTRAN; gage blocks; measurement assurance; statistical control; TN1168.

statistical tests; dimensional measurements; filar micrometer; image-shearing micrometer; integrated circuits; interlaboratory study; Kohler illumination; line-spacing measurements; linewidth calibration; linewidth measurements; measurement uncertainty; micrometrology; optical microscope; photomask; semiconductor technology; statistical methods; SP400-74.

statistical weights; symmetric top molecules; group theory; nuclear spin; rovibronic species; 21300.

statistics; training; accuracies, comparison of; government careers; in-service training; physics classroom experiments; statistical consulting course; 20947.

statistics; uncertainty limits; calibration; curve-fitting; 20800.

status and future; economic benefits; industry; International System of Units (SI); metric system; 21120.

steady velocity fields; Sun; Solar Maximum Mission; solar transition region; 21213.

steam; thermal response; valve; air conditioning; building systems; computer; control; heat exchanger; modeling; monitoring; research; 21048.

steam production; destruct heating; electricity production; energy recovery; incineration; New York City; resource recovery; solid waste management; NBS-GCR-82-409.

steel; ferrous scrap; iron; municipal solid waste; recycling; resource recovery; standards; 21358.

steel; walkway; building; collapse; connection; construction; failure; BSS143.

steel; wear; wear testing; chromium; coatings; electrodeposition; metallic glasses; nickel-phosphorus; 21232.

steel; wood; fire endurance; fire tests; flame through; floors; furnace tests; joists; NBSIR 82-2488.

steel frames; welding; brittle fracture; failure; fatigue; rapid transit; SP621; 1982 October. 110-129.

steel manufacturing; electroplating; Great Lakes region; hazardous waste management; paint manufacturing; resource recovery; solvent recovery; NBS-GCR-82-405.

stellar atmospheres; stellar chromospheres; stellar coronae; ultraviolet spectra; late-type stars; 21122.

stellar atmospheres; stellar chromospheres; ultraviolet spectrum; late-type stars; stars, individual; 20816.

stellar atmospheres; Voigt function; lineshape; radiative transfer; spectral line formation; 21148.

stellar chromospheres; stellar coronae; ultraviolet spectra; flare stars; late-type stars; 21405.



stellar chromospheres; stellar coronae; ultraviolet spectra; late-type stars; stellar atmospheres; *21122*.

stellar chromospheres; ultraviolet spectrum; late-type stars; stars, individual; stellar atmospheres; *20816*.

stellar coronae; ultraviolet spectra; flare stars; late-type stars; stellar chromospheres; *21405*.

stellar coronae; ultraviolet spectra; late-type stars; stellar atmospheres; stellar chromospheres; *21122*.

step response; analog-to-digital converters; code transition levels; converter testing; dynamic testing; high resolution; settling time; *20908*.

step response; divider; high voltage measurements; impulse; *SP628*; 1982 June. 26-33.

sticking; surface processes; x-ray edge; inelastic scattering; *21152*.

sticking; surface reaction dynamics; vibrational spectroscopy; *21286*.

stiffness; wind forces; anchors; cyclic loading; field testing; flood forces; foundations; load capacity; mobile homes; soil anchors; soil mechanics; *BSS142*.

stimulated emission; atomic collisions; close-coupled scattering theory; dressed-atoms; inelastic cross-sections; laser; laser-induced collisions; radiation theory; *21347*.

Stirling cycle; superconducting devices; cryocooler; cryogenics; low temperature; refrigerator; *TN1049*.

stochastic control theory; memory management; optimal memory allocation; *SP500-95*; 1982 October. 155-172.

stopping cross sections; adiabatic nuclei approximation; molecular collisions; *21074*.

stopping power; transport; bremsstrahlung; cross sections; elastic scattering; electron-impact ionization; electrons; photons; *NBSIR 82-2572*.

storage coil; superconductor; useful life; cable assembly; fatigue; stability; *21214*.

storage evaluation and analysis; environment; human health; National Environmental Specimen Bank; specimen banking; *21126*.

stored ions; atomic clock; atomic frequency standard; atomic spectroscopy; frequency standard; microwave frequency standard; optical frequency standard; *21202*.

stored ion spectroscopy; atomic clock; atomic frequency standard; atomic spectroscopy; ion storage; spectroscopy; *21285*.

stoves; tar; temperature measurements; wood; chimneys; creosote; fire safety; flues; heating equipment; *NBS-GCR-81-365*.

stoves; wall protection; walls; wood; chimneys; fire tests; flues; heating equipment; literature reviews; radiant energy; *NBSIR 82-2506*.

stoves; wood; chimneys; creosote; fire safety; fire tests; flues; heating equipment; *NBS-GCR-82-368*.

straight chain section; accordion-type oscillation; drawn polyethylene; gauche defect; Raman scattering; *20790*.

strain; surfaces; thermodynamics; coherency; composites; small particles; solid solutions; *20807*.

strategies; techniques; concepts; Information Resource Management; Information Systems Management; management-tool; methodologies; *SP500-95*; 1982 October. 5-9.

stratification; test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; NBS; solar; solar domestic hot water system; *BSS140*.

stratification; test method; water heater; energy conservation; energy consumption; flow control valve; heat pump; *NBSIR 81-2372*.

stratospheric ozone; chemical kinetics; flash photolysis; hydroxyl radicals; nitric acid; rate constant; resonance fluorescence; *21040*.

streak-camera; tunable; dye laser; mode-locked; picosecond; pulse emission; *21348*.

stream-depth; surge; transport; velocity; water; equation; flow; horizontal; motion; partially-filled pipe; slope; solid; *NBSIR 81-2450*.

streamer pulses; sulfurhexafluoride; water vapor; corona discharges; electron avalanches; gas chromatograph; mass spectrometer; SF<sub>6</sub>; *21379*.

streamers; transient phenomena; electrical breakdown; high speed photography; Kerr effect; liquid breakdown; nitrobenzene; partial discharges; *21328*.

stream function; vorticity; buoyant convection; finite difference computations; fire-enclosure; fluid flow; Lanczos smoothing; partial differential equations; *J. Res. 87(2)*: 165-185; 1982 March-April.

strength; building; collapse; concrete; concrete strength; construction; failure; flat plate; shear; *BSS145*.

strength; stress; toughness; collapse; cracks; defects; failure; fracture mechanics; girth welds; pipeline; plasticity; *21169*.

strength; subcritical crack growth; cracks; fracture; glass; static fatigue; *NBSIR 82-2524*.

stress; time dependent; unsteady; water tunnel; waves; drag; oscillatory flow; phase dependent; ripple; sand; sea bed; *21332*.

stress; toughness; collapse; cracks; defects; failure; fracture mechanics; girth welds; pipeline; plasticity; strength; *21169*.

stress analysis; surface preparation; surgical implant metals; test method; titanium; bone cement; hip prosthesis; *NBSIR 82-2563*.

stress analysis; x-ray diffraction; diffraction; high-energy x-rays; internal stress; neutron diffraction; nondestructive evaluation; residual stress; *21359*.

stress contours; concrete; crack propagation; failure surface geometry; failure theory; finite element method; internal strain; laboratory testing; large scale models; mathematical model; pullout test; *NBSIR 82-2484*.

stress-corrosion; computer controlled mechanical test; crack growth; creep-fatigue; mechanical testing; multiaxial tests; *21111*.

stress corrosion; structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; *21177*.

stress-crack resistance; stress-relaxation; ultra high molecular weight; creep; fatigue; morphology; polyethylene; *NBSIR 82-2493*.

stress measurement; terminology; ultrasonics; x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; residual stress; standards; *21344*.

stress measurements; ultrasonics; x-ray diffraction; Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; residual stress; *20926*.

stress-relaxation; ultra high molecular weight; creep; fatigue; morphology; polyethylene; stress-crack resistance; *NBSIR 82-2493*.

stress-rupture; fracture control; hazardous materials; impact transition; pressurized tank car; *SP621*; 1982 October. 18-32.

stress systems; tension loading; brittle materials; ductile materials; fatigue; fractures; machines; *SP621*; 1982 October. 196-200.

strong collisions; line broadening; model microfield; plasma; Stark; *20846*.

strontium; absolute ratios; atomic weight; isotopic abundances; *J. Res. 87(1)*: 1-8; 1982 January-February.

strontium; vacuum ultraviolet; yttrium; ion; laser-produced plasma; spectrum; *21356*.

strontium; vacuum ultraviolet; yttrium; zirconium; molybdenum; niobium; spectra; *21179*.

strontium phosphate; struvite-type structure; crystal structure; hydrated phosphate; *21180*.

structural; errors in variable; functional; large sample, convex; regression; statistical methods; *J. Res. 87(1)*: 67-70; 1982 January-February.

structural analysis; bridge; collapse; concrete; construction; failure investigation; falsework; field load tests; formwork; post-tensioning; *NBSIR 82-2593*.

structural ceramics; deformation maps; high temperatures; proof testing; reliability; silicon nitride; *NBSIR 81-2445*.

structural effects; structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); *20825*.

structural engineering; engineering data; inservice data; mathematical modeling; mechanical engineering; nondestructive evaluation; pipeline safety; reactor safety; reliability; risk analysis; statistical analysis; stress corrosion; *21177*.

structural engineering; wind; climatology; extreme winds; fluid mechanics; meteorology; *21212*.

structural relaxation; temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; *20836*.

structural research; thermal performance; building research; equipment research; fire research; geotechnical research; illumination; *20896*.

structure; air pollution; dioxirane; dipole moment; microwave spectrum; ozone-olefin reactions; *21340*.

structure; borane monoammoniate; electric dipole moment; microwave spectrum; molecular structure; rotational spectrum; *21337*.



structured interview; technical writing; case study; documentation; documentation guidelines; documentation organizations; documentation procedures; *SP500-94*; 1982 October. 143-151.

structured testing; measures; metric; program complexity; software testing; *SP500-99*.

structure-insensitive; structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; 20825.

structure-sensitive; W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; 20825.

struvite analogue; water-rich hydrates; crystal structure; hydration of XO<sub>4</sub> ion; magnesium arsenate hydrate; magnesium phosphate hydrate; 20873.

struvite-type structure; crystal structure; hydrated phosphate; strontium phosphate; 21180.

stylus; surface roughness; surface topography; disks; drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; *TN1151*.

subcritical crack growth; cracks; fracture; glass; static fatigue; strength; *NBSIR 82-2524*.

subharmonic generation; dispersive bistability; fluctuations; nonequilibrium phase transitions; nonlinear optics; optical bistability; second harmonic generation; self pulsing; 20918.

substitution weighing; weighing; constant loading; high precision; load cell; mass comparator; *J. Res. 87(1)*: 47-48; 1982 January-February.

substrate; vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; *TN1150*.

sulfate reducing bacteria; underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfovibrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; 21326.

sulfite ion; sulfur dioxide; aqueous solution; bibliography; bisulfite ion; chemical kinetics; oxidation; oxygen; *SP630*.

sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; *NSRDS-NBS72*.

sulfur; cadmium sulfide; chloride-doped cadmium sulfide; chlorine; hydrogen peroxide; ion chromatography; 20859.

sulfur; chemical interactions; deep-level measurements; defects; optical properties; silicon; 20842.

sulfur dioxide; aqueous solution; bibliography; bisulfite ion; chemical kinetics; oxidation; oxygen; sulfite ion; *SP630*.

sulfur dioxide removal; gas phase reaction; stabilized Criegee intermediate; *U.S. Patent 4,351,810*.

sulfur hexafluoride; corona discharge; corona pulse characteristics; decomposition products; gas chromatograph-mass spectrometer; H<sub>2</sub>O; 21247.

sulfurhexafluoride; water vapor; corona discharges; electron avalanches; gas chromatograph; mass spectrometer; SF<sub>6</sub>; streamer pulses; 21379.

sulfuric acid; THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; 20930.

summary; ultrasonics; bibliography; physical acoustics; *NBSIR 82-2529*.

Sun; Solar Maximum Mission; solar transition region; steady velocity fields; 21213.

Sun; supergranulation; atmospheric motions; chromosphere; 21377.

supercomputers; workload characterization; benchmarking; capacity planning; chargeback systems; computer performance management systems; queueing models; resource measurement facilities; simulation; *SP500-95*.

superconducting devices; cryocooler; cryogenics; low temperature; refrigerator; Stirling cycle; *TN1049*.

superconducting fixed points; thermometry; Josephson effect; Rh-Fe; SQUIDS; 21035.

superconducting interferometers; analog to digital converter; *U.S. Patent 4,315,255*.

superconductivity; Josephson junctions; noise thermometers; nonlinear differential equation; 21049.

superconductivity; supercurrent; tunneling; ac Josephson effect; dc Josephson effect; Josephson junctions; 21316.

superconductivity; superfluidity; tungsten; beryllium; fixed points; 21219.

superconductivity; temperature; transition temperature; tungsten; beryllium; fixed points; liquid <sup>3</sup>He; 21063.

superconductivity; tunneling; AuAl<sub>2</sub>; energy gap; 21351.

superconductor; critical current; critical temperature; electrical property; low-temperature; standard; 21014.

superconductor; magnetic susceptibility; magnetoresistivity; 21015.

superconductor; tin; titanium; copper; critical current; electrical property; magnetic field; measurement; niobium; 21218.

superconductor; useful life; cable assembly; fatigue; stability; storage coil; 21214.

superconductors; temperature fixed points; thermodynamic temperature; thermometry; tunnel diode oscillators; low-temperature gases; noise thermometry; nuclear orientation thermometry; 21018.

supercooling; Suzuki's scaling; time-dependent growth rate; unstable; nonlinear; relaxation; 21399.

supercurrent; tunneling; ac Josephson effect; dc Josephson effect; Josephson junctions; superconductivity; 21316.

superelastic collisions; associative ionization; energy pooling; lasers; photoelectron spectrum; 21221.

superfluidity; tungsten; beryllium; fixed points; superconductivity; 21219.

supergranulation; atmospheric motions; chromosphere; Sun; 21377.

SuperMite; CAMAC pulse processing modules; inertial confinement fusion; Sandia Particle Beam Fusion Accelerator; *SP628*; 1982 June. 325-340.

supermultiplets; atomic masses; binding energies; mass formula; nuclear shell effects; quartetting; 20939.

superposition; treatment planning; dosimetry; electrons; Monte Carlo; point-monodirectional beams; *NBSIR 82-2451*.

supply management; Thames Water Authority; United Kingdom; water conservation practices; demand management; *SP624*; 1982 June. 367-372.

surface analysis; Auger electrons; copper; gold; nickel; photoelectrons; 20986.

surface analysis; Auger-electron spectroscopy; round robin; 20927.

surface analysis; thin films; x-ray spectroscopy; Auger spectroscopy; depth profiling; sputtering; 20985.

surface analysis; x-ray photoelectron spectroscopy; Auger-electron spectroscopy; ESCA (electron spectroscopy for surface analysis); ion-scattering spectroscopy; secondary-ion mass spectroscopy; 21382.

surface charge conservation; transient propagation; arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; special relativity; 21327.

surface chemistry; surface structure; Al(111); ammonia; desorption; electron stimulated desorption ion angular distribution; 21172.

surface cleansing; test methods; volumetric efficiency; waste removal; water closets; residential water use; sanitary performance; *SP624*; 1982 June. 273-280.

surface conductivity; integrated circuits; moisture reliability; plastic encapsulation; *SP400-72*; 1982 April. 247-257.

surface conductivity; surface phenomena; adsorbed water; electrical conductivity; nonlocal process; *SP400-72*; 1982 April. 149-164.

surface conductivity moisture monitor; gas analysis; hermetic IC packages; in-situ moisture monitor; internal water vapor; moisture measurement; *SP400-72*; 1982 April. 64-75.

surface conductivity sensor; time response of moisture sensors; aluminum oxide moisture sensor; moisture sensors; pn junction temperature sensor; *SP400-72*; 1982 April. 79-89.

surface conductivity sensors; aluminum oxide sensors; Cerdip; Cerpak; leak detection; mass spectrometry; Method 1018; moisture sensors; *SP400-72*; 1982 April. 90-97.

surface-enhanced Raman spectroscopy; adsorption; electrode processes; N-methylpyridinium iodide; pyridine derivatives; Raman spectroscopy; silver electrode; 21262.

surface enhanced Raman spectroscopy (SERS); surface plasmons; surface roughness; adsorbed monolayers; Raman spectra of monolayers; 21068.

surface geometry; surface spectroscopy; field enhancement; molecular fluorescence; 21031.

surface magnetism; electron polarization; electron scattering resonances; spin; spin-orbit interaction; 20891.

surface melting; aluminum-silver alloys; cellular growth; electron



beam; interface velocity; rapid solidification; stability; 21263.

surface model; corrosion of an IC; IC surface; localized corrosion; SP400-72; 1982 April. 129-148.

surface modification; breakdown of passivity; corrosion; electrochemistry; passivity; repassivation; 20928.

surface phenomena; adsorbed water; electrical conductivity; nonlocal process; surface conductivity; SP400-72; 1982 April. 149-164.

surface plasmons; surface roughness; adsorbed monolayers; Raman spectra of monolayers; surface enhanced Raman spectroscopy (SERS); 21068.

surface potential barrier tungsten (100); surface resonance; electron diffraction; polarized low energy; spin-orbit splitting; 20976.

surface preparation; surgical implant metals; test method; titanium; bone cement; hip prosthesis; stress analysis; NBSIR 82-2563.

surface processes; x-ray edge; inelastic scattering; sticking; 21152.

surface reaction dynamics; vibrational spectroscopy; sticking; 21286.

surface reactions; trajectories; vibrational spectroscopy; electron-hole pairs; Franck-Condon factors; 21178.

surface recombination velocity; electrical test structure; gated diode; generation lifetime; integrated gated-diode electrometer; integrated test structure; leakage current; open-circuit voltage decay; 21143.

surface reconstruction; surface states; vibrational spectra; deuterium on diamond; diamond(111) 1×1; EELS; electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; 21288.

surface reflections; wave impedance; electromagnetic waves; graded materials; inhomogeneous media; jellium; optical reflections; reflection coefficient; Riccati equation; TN1171.

surface resonance; electron diffraction; polarized low energy; spin-orbit splitting; surface potential barrier tungsten (100); 20976.

surface roughness; adsorbed monolayers; Raman spectra of monolayers; surface enhanced Raman spectroscopy (SERS); surface plasmons; 21068.

surface roughness; surface topography; disks; drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus; TN1151.

surfaces; thermodynamics; coherency; composites; small particles; solid solutions; strain; 20807.

surfaces; uranium; hydride; hydrogen; microscopy; orthorhombic; 21021.

surface science; synchrotron radiation; photoelectron spectroscopy; 21099.

surface spectroscopy, field enhancement; molecular fluorescence; surface geometry; 21031.

surface states; vibrational spectra; deuterium on diamond; diamond(111) 1×1; EELS; electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; surface reconstruction; 21288.

surface structure; Al(111); ammonia; desorption; electron stimulated desorption ion angular distribution; surface chemistry; 21172.

surface temperature; absorption; ignition; polymethylmethacrylate; radiation; red oak; 21305.

surface temperature; ignition; ignition surface temperature; polymethylmethacrylate; radiative ignition; red oak; 21306.

surface temperature; wood; absorption; CO<sub>2</sub> laser; decomposition; ignition; polymethacrylate; radiation; 20792.

surface tension; thermophysical properties; tungsten; Auger spectroscopy; convection; gallium-tin alloys; levitation calorimetry; segregation; specific heat; NBSIR 82-2560.

surface topography; disks; drag; flow; friction disk; hulls; hydrodynamic drag; rotating disk; roughness; ships; stylus; surface roughness; TN1151.

SURF-II; calibration; electrons; instrumentation; photon detectors; 21053.

surge; transport; velocity; water; equation; flow; horizontal; motion; partially-filled pipe; slope; solid; stream-depth; NBSIR 81-2450.

surge attenuation; unsteady flow; building drainage; computer model; NBSIR 82-2478.

surgical implant metals; test method; titanium; bone cement; hip prosthesis; stress analysis; surface preparation; NBSIR 82-2563.

survey; teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; SP609; 1982 February. 89-97.

survivability; alternate routing; communications networks; distributed control; message delay; network throughput; 20994.

Suzuki's scaling; time-dependent growth rate; unstable; nonlinear; relaxation; supercooling; 21399.

switchboard model; gambler's ruin problem; Monte Carlo; polyethylene; polymer; polymer between two plates; rotational isomeric state model; 21138.

switchboard model of polymer surface; adjacent reentry model of crystal and amorphous phase in polymer; polymer; semicrystalline polymer; small angle neutron scattering; 21161.

symbiotic stars; mass exchange; RS Canum Venaticorum binaries; spectrophotometry; stars, individual; 20808.

symbols; visual alerting; warning; communication; design issues; hazard; pictograms; pictorial; safety; signs; standards; BSS141.

symmetric top molecules; group theory; nuclear spin; rovibronic species; statistical weights; 21300.

symposium; temperature scale; thermometers; thermometry; fixed points; J. Res. 87(5): 387-406; 1982 September-October.

symptom; test strategy; automated test equipment; fault isolation diagnostics; functional subsystem; line replaceable units; malfunction; microprocessor controlled test set; SP640; 1982 October. 223-234.

synchronization; syntonization; time scales; coordinate time; frequency standards; international atomic time; relativity; satellite clocks; SI second; 21188.

synchrotron radiation; asymmetry parameter; autoionization; branching ratios; innershell resonances; photoelectron spectroscopy; rare gases; 21291.

synchrotron; topography; x-ray image magnification; multocrystal diffraction; real time; 21259.

synchrotron radiation; acetylene; angular distribution; photoionization; 21006.

synchrotron radiation; autoionization; photoelectron spectroscopy; shape resonance; 21357.

synchrotron radiation; detector calibrations; electron storage rings; electron synchrotrons; 20776.

synchrotron radiation; energy deposition; extreme ultraviolet; high resolution; lithography; photoresists; 21078.

synchrotron radiation; photoelectron spectroscopy; surface science; 21099.

synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; ESD; oxygen; photon stimulated desorption; PSD; 20832.

synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; hydrogen; methanol; methoxy; oxygen; photon stimulated desorption; PSD; 21296.

synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; water; hydrogen; oxygen; photon stimulated desorption; PSD; 21005.

synchrotron radiation; topography; x ray; image formation; kinetic study; materials science; 21257.

synchrotron radiation; toroidal grating; ultrahigh vacuum; vacuum ultraviolet; grazing incidence; monochromator efficiency; 21069.

synchrotron radiation; toroidal grating monochromator; vacuum ultraviolet monochromator; far ultraviolet radiation; grating; monochromator; 21079.

synchrotron radiation; 1 keV photon energy region; beryl; KAP; metallic multilayers; reflectivity; resolving power; 21088.

synthetic hydrocarbon oils; aircraft hydraulic fluid; aircraft wheel bearing grease; instrument bearing lubrication; low temperature fluidity; SP640; 1982 October. 348-363.

synthetic sapphire; aluminum oxide; corundum; drop calorimetry; enthalpy; heat capacity; high temperature; standard reference material; J. Res. 87(2): 159-163; 1982 March-April.

synthetic software; acquisition benchmarks; benchmark construction; forecasting; SP500-95; 1982 October. 443-448.

syntonization; time scales; coordinate time; frequency standards; international atomic time; relativity; satellite clocks; SI second; synchronization; 21188.

system; calibration; intercomparisons; measurements; radioactivity; standards; SP609; 1982 February. 31-37.

system architecture; system components; database; database function; database management system; data model; schema; standards; SP500-86.

systematic uncertainty; units; data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; 20888.

system components; database; database function; database management system; data model; schema; standards; system architecture; SP500-86.

system decomposition; top-down; documentation; documentation



standards; FADPUG; software engineering; *SP500-94*; 1982 October. 166-171.

system design; teleprocessing systems; testing; external test driver; performance evaluation; remote terminal emulation; *SP500-95*; 1982 October. 415-421.

system fault isolation; thyatrons; current measurements; pulse power system; signal transmission; *SP628*; 1982 June. 248-255.

system monitoring; workload characterization; workload measurement; computer accounting; representative workload; *SP500-95*; 1982 October. 111-120.

system operation; accreditation; certification; functions; laboratory accreditation; product certification; *SP632*; 1982 March. 24-27.

system parameters; transportable computer software; ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; *TN1163*.

system performance; flow of information; on-line system; *SP500-95*; 1982 October. 41-45.

system performance indicators; computer performance evaluation; performance improvement plan; *SP500-95*; 1982 October. 75-80.

systems documentation; data processing documentation; *SP500-94*; 1982 October. 247-255.

systems life cycle; systems management; operation phase; software documentation; *SP500-94*; 1982 October. 58-67.

systems management; operation phase; software documentation; systems life cycle; *SP500-94*; 1982 October. 58-67.

systems performance; approximation techniques; queuing models; simulation; software package; *SP500-95*; 1982 October. 139-154.

systems planning and control; ADP planning; Federal ADP procurement; life cycle management; long-range planning; *SP500-95*; 1982 October. 11-18.

systems security; documentation life cycle; *SP500-94*; 1982 October. 131-142.

system under tests; interactive system; performance evaluation; remote terminal emulation; remote terminal emulator; *SP500-95*; 1982 October. 409-413.

system verification; user information; users manual; quality control; quality control tool; *SP500-94*; 1982 October. 256-264.

## T

tables; ASTM E162; fire tests; flame spread; plastics; smoke chamber; *NBSIR 81-2400*.

tabulation; water; x rays; coherent scattering; cross section; form factor; Rayleigh scattering; *JPCRD 11(4)*: 1091-1098; 1982.

tagged photon method; Bethe-Heitler cross section; bremsstrahlung monochromator; photonuclear research; polarized bremsstrahlung differential cross section; polarized photon beams; *NBSIR 82-2454*.

tantalum; tungsten; ytterbium; barium; dysprosium; energy levels; erbium; gadolinium; neodymium; samarium; spectrum; *20845*.

tantalum oxide; lithium tantalate; neutron diffraction; powder method; Rietveld method; solid solution; *21157*.

TAPPI; tenth anniversary; testing; Collaborative Reference Program; paper; *21244*.

tar; temperature measurements; wood; chimneys; creosote; fire safety; flues; heating equipment; stoves; *NBS-GCR-81-365*.

target designators; computer simulation; laser beam profile; mode-matching analysis; spatial filter; *TN1057*.

task force; international; international trade; laboratory accreditation; *SP632*; 1982 March. 43-45.

task force C; American Association for Laboratory Accreditation; International Laboratory Accreditation Conference; laboratory accreditation system; *SP632*; 1982 March. 73.

task lighting; building energy performance; building subsystem energy criteria; energy conservation in lighting; general lighting; illumination energy; lighting energy; *21042*.

taximeters; tolerances; user requirements; volume-measuring devices; weights; length-measuring devices; liquid-measuring devices; measures; scales; specifications; *H44*.

Tb; wavelength; Ce; energy levels; Eu; Gd; Ho; Nd; Pr; Sm; *20877*.

technical activities 1981; thermochemical and thermophysical data; data compilation; energy and environmental data; evaluated data; materials data; standard reference data; *NBSIR 81-2442*.

Technical Advisory Group; ASTM; building materials; fire resistance; fire tests; international; ISO; standards; *21139*.

technical bases; building research; building technology; codes; criteria; measurement methods; performance criteria; project

summaries; *SP446-6*.

technical information programs; technical information retrieval; American Water Works Association; *SP624*; 1982 June. 37-45.

technical information retrieval; American Water Works Association; technical information programs; *SP624*; 1982 June. 37-45.

technical writing; case study; documentation; documentation guidelines; documentation organizations; documentation procedures; structured interview; *SP500-94*; 1982 October. 143-151.

techniques; concepts; Information Resource Management; Information Systems Management; management-tool; methodologies; strategies; *SP500-95*; 1982 October. 5-9.

techniques, spectroscopic; FT-IR; infrared; interferograms, tertiary; methods, analytic; silicon; *20828*.

technology centers; technology innovation; maintenance; maintenance costs; maintenance technology; *SP640*; 1982 October. 17-26.

technology innovation; maintenance; maintenance costs; maintenance technology; technology centers; *SP640*; 1982 October. 17-26.

technology in truck maintenance; truck maintenance aids; automated test equipment; diagnostics; *SP621*; 1982 October. 201-211.

technology policy; administrative experiments; economic assistance; innovation; procurement; regulation; research and development; *NBS-GCR-ETIP 82-100*.

technology transfer; technology utilization; evaluation; Federal R&D; industry; innovation; State and local governments; *20854*.

technology transfer; training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; *SP629*.

technology utilization; evaluation; Federal R&D; industry; innovation; State and local governments; technology transfer; *20854*.

tectonics; absolute gravity; geodesy; geophysics; gravity; *21318*.

teflon; crosslinking; dosimetry; ethylene vinyl acetate; initial modulus; melt index; melting point; polyethylene stresscrack polytetrafluoroethylene radiochromic dyes; quality control radiation processing; radiation crosslinking; *20900*.

telecommunications; computer networks; distributed data; Government and industry; protocol standards; *21265*.

telephone cables; underground; alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; *NBSIR 82-2509*.

teleprocessing services procurements; unbalanced pricing; workload forecasting; basic agreement solicitations; evaluation of system life costs; *SP500-95*; 1982 October. 27-33.

teleprocessing systems; testing; external test driver; performance evaluation; remote terminal emulation; system design; *SP500-95*; 1982 October. 415-421.

telescope; x ray; digitizing anode; gamma ray; microchannel plate; multiple-pinhole mask; spectrometer; *21366*.

teletherapy; thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; survey; *SP609*; 1982 February. 89-97.

TEM cell; total radiated power; dipole moments; electrically small; interference source; leakage; phase measurements; power measurements; radiation pattern; *TN1059*.

TEM cell; variational method; Green's function; input impedance; probe antenna; radiation resistance; rectangular coaxial transmission line; *TN1054*.

temperature; fluid flow; instrumentation; irradiance; measurements; solar; *21349*.

temperature; transition temperature; tungsten; beryllium; fixed points; liquid <sup>3</sup>He; superconductivity; *21063*.

temperature; tunnel diode; tunnel diode oscillator; LC oscillator; oscillator sensor; pressure; pulsed oscillator; pulsed sensor; *21064*.

temperature drifts; thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; *NBSIR 81-2393*.

temperature drifts/comfort; thermal comfort; ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; *NBSIR 82-2585*.

temperature effects; dosimetry; dyes; gamma radiation; plastic films; polymethyl methacrylate; radiation processing; radiochromic dyes; red Perspex; relative humidity effects; *20975*.

temperature effects on surface water; accelerated moisture testing; microenvironments; moisture related failures; *SP400-72*; 1982 April.



165-174.

temperature fixed points; thermistor thermometers; thermocouple thermometers; thermodynamic temperatures; thermometry; automatic resistance bridges; gas thermometry; high-temperature platinum resistance thermometers; 21019.

temperature fixed points; thermodynamic temperature; thermometry; tunnel diode oscillators; low-temperature gases; noise thermometry; nuclear orientation thermometry; superconductors; 21018.

temperature measurements; wood; chimneys; creosote; fire safety; flues; heating equipment; stoves; tar; *NBS-GCR-81-365*.

temperature phases; hydrogen chemisorption; PLEED; spin dependent electron scattering; 20865.

temperature profile; thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; 20836.

temperature programmed desorption; carbon monoxide; chemisorption; isotopic exchange; nickel; 20863.

temperature scale; thermometers; thermometry; fixed points; symposium; *J. Res. 87(5)*: 387-406; 1982 September-October.

tenability limits; combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; *NBSIR 82-2578*.

tensile properties; weathering of cover plates; artificial weathering; cover plate materials; durability; natural weathering; solar collectors; solar energy; solar energy transmittance; *TN1170*.

tensile strength; test methods; elongation; exposure conditions; membrane properties; roofing membranes; single-ply roofing; 20841.

tension loading; brittle materials; ductile materials; fatigue; fractures; machines; stress systems; *SP621*; 1982 October. 196-200.

tenth anniversary; testing; Collaborative Reference Program; paper; TAPPI; 21244.

terbium; glass; luminescence; melts; oxidation; reduction; 21315.

terminals; disk units; Federal Government computers; Federal minicomputers; Federal statistics; general purpose computers; magnetic tape units; *SP500-97*.

terminology; ultrasonics; x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; residual stress; standards; stress measurement; 21344.

term relations; automatic indexing; concept relations; co-occurrence; document retrieval; independence assumption; information retrieval; information retrieval research and development; information retrieval systems; information retrieval theory; models of concept relations; similarity; 21250.

ternary superconductors; antiferromagnetic superconductors; chevron phase;  $\text{ErRh}_2\text{B}_4$ ; ferromagnetic superconductors; neutron scattering; 21131.

test apparatus; test method; adhesion; measurement; protective coatings; *NBSIR 82-2535*.

test chip; test pattern; test structure; yield; integrated circuits; microelectronics; process control; process validation wafer; silicon on sapphire; *NBSIR 82-2514*.

test chip; test structure; custom; integrated circuits; multifunction; parametric tester; reliability; standard; 20835.

test coverage; test data generation; validation; automated software tools; software lifecycle; software testing; software verification; *SP500-98*.

test coverage; validation; V,V&T techniques; V,V&T tools; automated software tools; dynamic analysis; formal analysis; software testing; software verification; static analysis; *SP500-93*.

test data; toxic substances; laboratory; *SP632*; 1982 March. 79-80.

test data generation; validation; automated software tools; software lifecycle; software testing; software verification; test coverage; *SP500-98*.

test development; textiles; upholstered furniture; cigarettes; fabrics; flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; 21128.

test facilities; certifiers; evaluation; International Electrotechnical Commission; laboratory; *SP632*; 1982 March. 74-75.

testing; ASTM committee E-36; inspection agencies; laboratories; *SP632*; 1982 March. 68-69.

testing; Collaborative Reference Program; paper; TAPPI; tenth anniversary; 21244.

testing; commercial laboratories; concrete; laboratory accreditation; NVLAP; *SP632*; 1982 March. 54-56.

testing; composite materials; laminate structure; maintenance; repairability; sandwich structure; *SP640*; 1982 October. 364-378.

testing; defect detection; eddy current; failure prevention; ferromagnetic alloys; inspection; metal distress; metal parts; NDE; nickel base alloys; *SP640*; 1982 October. 454.

testing; energy; heat transfer; hot water; measurement; rating; solar; standards; 21264.

testing; external test driver; performance evaluation; remote terminal emulation; system design; teleprocessing systems; *SP500-95*; 1982 October. 415-421.

testing; traceability; visibility; product assurance; software maintenance; *SP500-94*; 1982 October. 23-29.

testing; voltage; clamping; diode recovery; high power measurements; high voltage; overshoot; power semiconductors; reverse-bias second breakdown; 20849.

testing laboratories; accreditation; laboratory; legal system; standards code; *SP632*; 1982 March. 40-42.

testing laboratory; laboratory accreditation; product certification program; *SP632*; 1982 March. 70-72.

testing program; conversion factors; dose equivalent; field measurement; Health Physics Society; neutrons; photons; standard; 20813.

test method; adhesion; measurement; protective coatings; test apparatus; *NBSIR 82-2535*.

test method; ASHRAE Standard 95; collectors in parallel; electric strip heaters; environmental conditions; indoor testing; modeling; NBS; solar; solar domestic hot water system; stratification; *BSS140*.

test method; ASHRAE 95; collectors; solar domestic hot water; solar simulator; standard; 20940.

test method; central air conditioners; heat pumps; rating procedure; seasonal cost of operation; *NBSIR 81-2434*.

test method; titanium; bone cement; hip prosthesis; stress analysis; surface preparation; surgical implant metals; *NBSIR 82-2563*.

test method; toxicity; combustion products; flaming combustion; inhalation; materials; nonflaming combustion; *NBSIR 82-2532*.

test method; water heater; energy conservation; energy consumption; flow control valve; heat pump; stratification; *NBSIR 81-2372*.

test method; water source heat pumps; central heating equipment; cooling; heating; heating seasonal performance; heating seasonal performance factor; heat pumps; *NBSIR 81-2287*.

test method development; hail damage; hail impact testing; hail launcher; simulated hail testing; solar collector covers; *NBSIR 82-2487*.

test methods; ASTM E-5; fire tests; histories; 20789.

test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; 21121.

test methods; calorimeters; correlation; energy transfer; fire tests; flame spread; ignition; mass loss; *NBSIR 82-2536*.

test methods; elongation; exposure conditions; membrane properties; roofing membranes; single-ply roofing; tensile strength; 20841.

test methods; integrated circuits; microelectronic test chips; parametric testers; 20956.

test methods; visibility; correlation; fire tests; full-scale; smoke; smoke density chamber; optical density; *NBSIR 82-2508*.

test methods; volumetric efficiency; waste removal; water closets; residential water use; sanitary performance; surface cleansing; *SP624*; 1982 June. 273-280.

test pattern; test structure; wafer map; integrated circuits; microelectronics; process control; process validation wafer; 20838.

test pattern; test structure; yield; integrated circuits; microelectronics; process control; process validation wafer; silicon on sapphire; test chip; *NBSIR 82-2514*.

test procedures; basestock; engine lubricants; lubricating oil; motor oil; petroleum oil; recycled oil; re-refined oil; 20990.

test procedures; code provisions; passive solar systems; performance criteria; solar energy; standards; 21119.

test protocols; analytical procedures; hazardous waste management; lab procedures; model manual; monitoring; Resource Conservation and Recovery Act; State measurement needs; *NBS-GCR-81-355*.

test protocols; Texas; training; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; *NBS-GCR-81-352*.

test protocols; training; analytical procedures; hazardous waste management; lab procedures; Oklahoma; Resource Conservation and Recovery Act; *NBS-GCR-81-350*.

test protocols; training; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; *NBS-GCR-81-348*.

test protocols; training; analytical procedures; hazardous waste



management; lab procedures; Pennsylvania; Resource Conservation and Recovery Act; *NBS-GCR-81-351*.

test protocols; training; analytical procedures; hazardous waste management; lab procedures; Mississippi; Resource Conservation and Recovery Act; *NBS-GCR-81-353*.

test protocols; training; analytical procedures; hazardous waste management; lab procedures; Louisiana; Resource Conservation and Recovery Act; *NBS-GCR-81-349*.

test protocols; training; Virginia; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; *NBS-GCR-81-354*.

tests; thermal conductivity; thermal resistivity; Atterberg Limit tests; compaction; compaction tests; heat flow; laboratory tests; soil moisture; soil tests; *BSSI149*.

tests for systematic error; uncertainty; IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; *TN1164*.

test strategy; automated test equipment; fault isolation diagnostics; functional subsystem; line replaceable units; malfunction; microprocessor controlled test set; symptom; *SP640*; 1982 October. 223-234.

test structure; cross-bridge structure; linewidth; microelectronic test structure; process control; sheet resistance; *NBSIR 82-2548*.

test structure; custom; integrated circuits; multifunction; parametric tester; reliability; standard; test chip; *20835*.

test structure; wafer map; integrated circuits; microelectronics; process control; process validation wafer; test pattern; *20838*.

test structure; yield; integrated circuits; microelectronics; process control; process validation wafer; silicon on sapphire; test chip; test pattern; *NBSIR 82-2514*.

test structures; avalanche injection; capacitance-voltage curves; charge injection; charge pumping; gated diodes; interface states; metal-oxide-semiconductor devices; microelectronic test structures; MOSFETs; neutral traps; oxide-semiconductor interface; *NBSIR 81-2413*.

tetrafluoroethylene; vinylidene fluoride; charge transport; copolymer; electrical properties; piezoelectricity; poling; pyroelectricity; *20840*.

tetrafluoroethylene; x-ray diffraction; copolymers; crystal; hexafluoropropylene; polytetrafluoroethylene; *21164*.

tetragonal; Burgers vector; defect; dislocation; glide; inclusion; kink; *20973*.

tetramethyltin; tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; *20999*.

Texas; training; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; *NBS-GCR-81-352*.

text formatters; data documentation; machine-readable; *SP500-94*; 1982 October. 203-208.

textiles; directory; ferrous metals; glass; nonferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; *NBS-GCR-82-366*.

textiles; upholstered furniture; cigarettes; fabrics; flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; *21128*.

THAM; TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; *20930*.

Thames Water Authority; United Kingdom; water conservation practices; demand management; supply management; *SP624*; 1982 June. 367-372.

Tharp's algorithm; assignment; Brent's algorithm; double hashing; requirements; retrieval; *21248*.

theory; hydrogen in metals; impurity tunneling; KBr:CN<sup>-</sup>; KCl:CN<sup>-</sup>; neutron scattering; phonon coupling; *20879*.

thermal analysis; bearing failure; bearing reliability; condition monitoring; roller bearings; *SP640*; 1982 October. 295-325.

thermal annealing; annealing; boron; ion implantation; laser annealing; local mode; optical spectra; phonons; Raman spectra; silicon; spectra; *21091*.

thermal comfort; ASHRAE comfort standards; asymmetric heating/comfort; behavioral studies; clothing/thermal comfort; comfort envelope; human factors; passive solar/thermal comfort; performance/thermal comfort; temperature drifts/comfort; *NBSIR 82-2585*.

thermal comfort; bioclimatic chart; human comfort; indoor environment; outdoor environment; *21004*.

thermal comfort condition; Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; *NBSIR 81-2393*.

thermal conductance; thermal conductivity; thermal resistance; built-up roofing; insulation; moisture; roofing; *21354*.

thermal conductance of building sections; ASTM C-236; calibrated and guarded hot boxes; interlaboratory round robin tests; *NBSIR 81-2443*.

thermal conductivity; convection; foam; gas conduction; guarded-hot-plate; insulation; low temperature; radiation; solid conduction; *NBSIR 82-1664*.

thermal conductivity; guarded-hot-plate apparatus; insulation; low-temperature; *NBSIR 81-1657*.

thermal conductivity; thermal resistance; built-up roofing; insulation; moisture; roofing; thermal conductance; *21354*.

thermal conductivity; thermal resistance; thickness effect; building insulation; energy conservation; guarded hot plate; heat flow meter; heat transfer; low-density mineral fiber; *NBSIR 82-2538*.

thermal conductivity; thermal resistivity; Atterberg Limit tests; compaction; compaction tests; heat flow; laboratory tests; soil moisture; soil tests; tests; *BSSI149*.

thermal conductivity; transient; hot wire; oxygen; pressure temperature; *J. Res. 87(4)*: 279-310; 1982 July-August.

thermal conductivity; transient hot wire; liquid; propane; *20831*.

thermal degradation; ceilings; charring; compartment fires; corridors; flame spread; polymers; room fires; *NBS-GCR-82-377*.

thermal deposition systems; thermospray process; wear; aluminum non-skid coating; corrosion control; erosion; flame spray process; plasma coatings; *SP640*; 1982 October. 194-196.

thermal desorption; adsorption; carbon monoxide on Ni(111); electron stimulated desorption; ESDIAD; low energy electron diffraction; *21100*.

thermal diffusivity; calorimetry; Fourier equation; radiative cooling; specific heat; *J. Res. 87(6)*: 513-526; 1982 November-December.

thermal expansion; chain conformation; crystalline transformation; Curie temperature; dielectric anomaly; ferroelectric-paraelectric transition; intramolecular transformation; piezoelectricity; polytrifluoroethylene; pyroelectricity; *21395*.

thermal ionization mass spectrometry; isotopic analysis; isotopic fractionation; sample dryer; *TN1154*.

thermally stimulated measurements; thermometry; deep level measurements; measurement methods; semiconductor materials characterization; semiconductors; *21144*.

thermal performance; active solar; evaluation process; hot water; passive solar; performance criteria; solar energy; *NBS-GCR-82-397*.

thermal performance; building research; equipment research; fire research; geotechnical research; illumination; structural research; *20896*.

thermal performance; uncertainty; collector rating; incident angle modifier; measurement; solar collector; standards; *21387*.

thermal properties; thermodynamic properties; thermophysical properties; basalt; chemical characterization; data compilation; dielectric properties; electrical properties; mechanical properties; *NBSIR 82-2587*.

thermal pulse experiment; charge distribution; computer analysis; data reduction; Fourier analysis; piezoelectric polymers; polarization distribution; *21155*.

thermal relaxation; continuum mechanics; dense liquid; hydrostaticity; Lennard-Jones potential; molecular dynamics; Navier-Stokes equations; nonequilibrium processes; second sound; shock wave profile; structural relaxation; temperature profile; *20836*.

thermal resistance; built-up roofing; insulation; moisture; roofing; thermal conductance; thermal conductivity; *21354*.

thermal resistance; thickness effect; building insulation; energy conservation; guarded hot plate; heat flow meter; heat transfer; low-density mineral fiber; thermal conductivity; *NBSIR 82-2538*.

thermal resistivity; Atterberg Limit tests; compaction; compaction tests; heat flow; laboratory tests; soil moisture; soil tests; tests; thermal conductivity; *BSSI149*.

thermal response; automatic sprinklers; compartment fires; fire safety; life safety; room fires; sidewall sprinkler systems; *NBSIR 82-2521*.

thermal response; valve; air conditioning; building systems; computer; control; heat exchanger; modeling; monitoring; research; steam; *21048*.



thermal response; ventilation; air conditioning; air distribution; building systems; computer; control; modeling; office building; 21047.

thermal response factors; building heat transfer; DoE-2 energy analysis computer program; monthly average earth temperature; *NBSIR 81-2420*.

thermal response factors; thermostat control; burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; residential furnaces; room temperature; 20903.

thermal shock; Cerdip; glass sealed; integrated circuit; packages; quality control; *SP400-72*; 1982 April. 234-238.

thermal shock; vibration; acoustic emission; hermeticity; hybrid microelectronics; hybrid packages; microelectronic packaging; *SP400-70*.

thermal switch sensor; train line; contact derailment sensor; g-sensing derailment detector; local derailment; nitinol sensor; on-board failure detection system; overheated bearings; *SP621*; 1982 October. 49-68.

thermistor; water; absorbed dose; calorimeter; convection; heat defect; radiation chemistry; *J. Res. 87(3)*: 211-235; 1982 May-June.

thermistor; water calorimeter; absorbed dose; adiabatic; calorimeter; polyethylene film; *U.S. Patent 4,312,224*.

thermistors; EPT-76; germanium resistance thermometers; IPTS-68; magnetic thermometers; NQR thermometers; rhodium-iron thermometers; 20933.

thermistor thermometers; thermocouple thermometers; thermodynamic temperatures; thermometry; automatic resistance bridges; gas thermometry; high-temperature platinum resistance thermometers; temperature fixed points; 21019.

thermochemical and thermophysical data; data compilation; energy and environmental data; evaluated data; materials data; standard reference data; technical activities 1981; *NBSIR 81-2442*.

thermochemical tables; activity coefficients; binary aqueous systems; enthalpies of dilution; enthalpy; entropy; flue gas desulfurization; Gibbs energy osmotic coefficients; *NBSIR 81-2345*.

thermochemical tables; critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; *JPCRD 11(3)*: 695-940; 1982.

thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; 21255.

thermochemistry; alkylidioxo; carbene oxidation; Criegee intermediate; disproportionation reactions; elementary reactions; energetics; formaldehyde photooxidation; gas phase; ozone-alkene reactions; secondary ozonide; 21254.

thermochemistry; chemical thermodynamics; enthalpy; entropy; evaluated data; Gibbs energy; inorganic chemistry; *JPCRD 11(Suppl. 2)*: 394 pp.; 1982.

thermocouple thermometers; thermodynamic temperatures; thermometry; automatic resistance bridges; gas thermometry; high-temperature platinum resistance thermometers; temperature fixed points; thermistor thermometers; 21019.

thermodynamic properties; activity coefficient; critical evaluation; electrolyte; excess Gibbs energy; osmotic coefficient; solutions; 20936.

thermodynamic properties; coexistence; ethylene; heat capacity; saturated liquid; specific heat; 21187.

thermodynamic properties; thermophysical properties; argon; critically evaluated data; density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

thermodynamic properties; thermophysical properties; basalt; chemical characterization; data compilation; dielectric properties; electrical properties; mechanical properties; thermal properties; *NBSIR 82-2357*.

thermodynamic properties; transport properties; activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; *NBSIR 81-2356*.

thermodynamic properties; vapor pressure; enthalpy; equation of state; heavy water; Helmholtz function; *PVT*; specific heats; speed of sound; *JPCRD 11(1)*: 1-14; 1982.

thermodynamic properties; velocity of sound; virial coefficients; equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; speed of sound; 21208.

thermodynamics; activity coefficient; electrolyte; excess Gibbs energy; isopiestic; nickel nitrate; osmotic coefficient; solubility; solutions; 21234.

thermodynamics; activity coefficient; electrolytes; excess Gibbs energy; isopiestic; osmotic coefficient; potassium carbonate; solubility; solutions; 21233.

thermodynamics; coherency; composites; small particles; solid solutions; strain; surfaces; 20807.

thermodynamics; elements; enthalpy; entropy; evaluated data; heat capacity; 20819.

thermodynamics; transpiration; vaporization; boric oxide; glass; sodium boron; sodium borosilicate; 21108.

thermodynamics of the steady state; computer simulation; Couette flow; Lennard-Jones fluid; nonequilibrium molecular dynamics; nonlinear phenomena; phase changes; stability criteria; 20959.

thermodynamics properties; activity coefficient; correlation; critical evaluation; electrolyte theories; models; osmotic coefficient; polyvalent electrolytes; 20935.

thermodynamic temperature; thermometry; tunnel diode oscillators; low-temperature gases; noise thermometry; nuclear orientation thermometry; superconductors; temperature fixed points; 21018.

thermodynamic temperatures; thermometry; automatic resistance bridges; gas thermometry; high-temperature platinum resistance thermometers; temperature fixed points; thermistor thermometers; thermocouple thermometers; 21019.

thermoelement; ac current measurements; ac voltage measurements; ac-dc comparator; ac-dc difference; *TN1166*.

thermogram; cellulose; combustion; flame; inhibition; inorganic; powder; pyrolysis; retardant; smolder; 20799.

thermoluminescence; calibration; dosimetry; environmental; intercomparison; standards; *SP609*; 1982 February. 111-116.

thermoluminescence dosimetry; traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; survey; teletherapy; *SP609*; 1982 February. 89-97.

thermometers; thermometry; fixed points; symposium; temperature scale; *J. Res. 87(5)*: 387-406; 1982 September-October.

thermometric fixed point; tin point; triple point; zinc point; aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); *SP260-77*.

thermometry; automatic resistance bridges; gas thermometry; high-temperature platinum resistance thermometers; temperature fixed points; thermistor thermometers; thermocouple thermometers; thermodynamic temperatures; 21019.

thermometry; deep level measurements; measurement methods; semiconductor materials characterization; semiconductors; thermally stimulated measurements; 21144.

thermometry; fixed points; symposium; temperature scale; thermometers; *J. Res. 87(5)*: 387-406; 1982 September-October.

thermometry; Josephson effect; Rh-Fe; SQUIDS; superconducting fixed points; 21035.

thermometry; tunnel diode oscillators; low-temperature gases; noise thermometry; nuclear orientation thermometry; superconductors; temperature fixed points; thermodynamic temperature; 21018.

thermophysical properties; argon; critically evaluated data; density; ethylene; heat capacity; nitrogen; nitrogen trifluoride; oxygen; parahydrogen; thermodynamic properties; *JPCRD 11(Suppl. 1)*: 354 pp.; 1982.

thermophysical properties; basalt; chemical characterization; data compilation; dielectric properties; electrical properties; mechanical properties; thermal properties; *NBSIR 82-2587*.

thermophysical properties; tungsten; Auger spectroscopy; convection; gallium-tin alloys; levitation calorimetry; segregation; specific heat; surface tension; *NBSIR 82-2560*.

thermoplastic pool fires; wood crib fires; compartment fires; fire endurance; fire engineering design; liquid pool fires; 21093.

thermosetting polymers; varnishes; adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; specific heat; 21032.

thermospray process; wear; aluminum non-skid coating; corrosion control; erosion; flame spray process; plasma coatings; thermal deposition systems; *SP640*; 1982 October. 194-196.

thermostat control; burner on-time; cyclic rates; dynamic simulation computer model; fuel consumption; mobile home; overall system efficiency; residential furnaces; room temperature; thermal response



factors; 20903.

thickness effect; building insulation; energy conservation; guarded hot plate; heat flow meter; heat transfer; low-density mineral fiber; thermal conductivity; thermal resistance; *NBSIR 82-2538*.

thin film; transmittance extrema; electro-optic modulation; hydrogenated amorphous silicon; optical transmittance; refractive index; scattering matrix; *NBSIR 81-1652*.

thin films; aluminium; clusters; copper; gold; silver; single crystal; 21012.

thin films; ellipsometry; polysilicon films; silicon dioxide films; silicon nitride films; standard reference materials; 21107.

thin films; x-ray spectroscopy; Auger spectroscopy; depth profiling; sputtering; surface analysis; 20985.

thin layer spectroelectrochemistry; vacuum; methyl viologen; nonaqueous; 20872.

thiolane; concerted reaction; cyclobutane; ozonation; 20958.

third generation ATE; third generation core system; ATE systems; calibration; computer; hardware; measurement; *SP640*; 1982 October. 222.

third generation core system; ATE systems; calibration; computer; hardware; measurement; third generation ATE; *SP640*; 1982 October. 222.

third-order solution; transformation; artificial satellite; Hamiltonian; parallax transformation; 21381.

Thomson Parabola charged particle analyser; magnetic insulating voltage measurement; negative ions; *SP628*; 1982 June. 87-94.

Thomson spectrometer; charge to mass ratio; energy resolved emittance; energy spectrum; *SP628*; 1982 June. 257-265.

thorium; wavelengths; actinide; energy; energy levels; ionization parametric interpretation; 20878.

thoron; calibration; measurements; radiation; radon; radon progeny; standards; states; *NBS-GCR-82-394*.

three volume calibration valve; three volume calibrator; water-vapor measurement; mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; moisture measurement; *SP400-72*; 1982 April. 8-14.

three volume calibrator; water-vapor measurement; mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; moisture measurement; three volume calibration valve; *SP400-72*; 1982 April. 8-14.

throughput; transition matrix; carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; *SP500-95*; 1982 October. 365-373.

thytrons; current measurements; pulse power system; signal transmission; system fault isolation; *SP628*; 1982 June. 248-255.

thyristor; aluminum-doped silicon; dopant profiles; gallium doped silicon; resistivity profiles silicon; spreading resistance; 21083.

tie molecules; amorphous phase; crystal-amorphous interface; fold surface; loops; polymer; semicrystalline polymer; 21159.

time; time ball; time dissemination; Naval Observatory; navigation; observatory; 21023.

time and frequency metrology; time comparisons; Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; satellite; shuttle time; 21201.

time ball; time dissemination; Naval Observatory; navigation; observatory; time; 21023.

time ball; time signals; chronometers; Greenwich; Royal Observatory; 21024.

time comparisons; Doppler cancellation; frequency reference; generation of UTC and TAI; hydrogen maser clocks; international time; laser ranging; satellite; shuttle time; time and frequency metrology; 21201.

time dependent; unsteady; water tunnel; waves; drag; oscillatory flow; phase dependent; ripple; sand; sea bed; stress; 21332.

time-dependent growth rate; unstable; nonlinear; relaxation; supercooling; Suzuki's scaling; 21399.

time development; transient effects; ionisation; linear polarization; monochromatic resonance; multiphoton; perturbation theory; radiation; sodium atom; 21075.

time dissemination; Naval Observatory; navigation; observatory; time; time ball; 21023.

time domain; transient recorder; analog-to-digital converter; digitizer; dynamic testing; effective number of bits; frequency domain; quantizing error; signal-to-noise ratio; *SP634*; 1982 June. 7-21.

time-domain analysis; tool breakage; vibration sensing; drill breakage; Drill-Up; drill wear; *NBSIR 82-2590*.

time-domain analysis; tool failure; tool wear; vibration signatures; automated manufacturing; drill failure prediction; drill wear; finished dimensions; improper drilling; 20795.

time domain measurements; transfer standards; transition duration; waveform generation; waveform measurements; calibration; reference waveform generators; rise time; *SP634*; 1982 June. 69-88.

time domain measurements; waveform measurements; waveform recorders; errors; pulse measurements; *SP634*; 1982 June. 1-5.

time-domain stability; white noise; flicker noise; frequency-domain stability; frequency stability; oscillator noise modeling; power law spectrum; 21209.

time-domain stability; white noise; flicker noise; frequency stability; oscillator noise modeling; power law spectra; 21284.

timekeeping; frequency drift; frequency stability; hydrogen hyperfine separator; hydrogen maser; 21192.

timer; watt-hour meter; counter; 21266.

time response of moisture sensors; aluminum oxide moisture sensor; moisture sensors; pn junction temperature sensor; surface conductivity sensor; *SP400-72*; 1982 April. 79-89.

time scales; coordinate time; frequency standards; international atomic time; relativity; satellite clocks; SI second; synchronization; syntonization; 21188.

time-sharing; user level workloads; Ethernet; Ethernet performance; Ethernet simulation; higher level protocols; interactive program development; layered architecture; *SP500-95*; 1982 October. 375-388.

time signals; chronometers; Greenwich; Royal Observatory; time ball; 21024.

tin; atomic absorption spectroscopy; biocide; chromatography; copolymers; kinetics; NMR; organometallic polymers; polymers; size exclusion chromatography; slow-release antifoulant; *NBSIR 81-2424*.

tin; titanium; copper; critical current; electrical property; magnetic field; measurement; niobium; superconductor; 21218.

tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; tin IV; 20999.

tin IV; tin (II) tributyltin; atomic absorption detector; bacterial accumulation; bacterial methylation; flame photometric detector; gas chromatography; high pressure liquid chromatography; methylstannanes; purge/and trap sampling; tetramethyltin; 20999.

tin point; triple point; zinc point; aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; *SP260-77*.

tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); 20955.

tire inspection; ultrasonics; visual-optical; acoustic emission; eddy currents; liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; radiography; 20957.

titanium; alloys; anodic polarization; corrosion; fatigue; microstructures; 21174.

titanium; bone cement; hip prosthesis; stress analysis; surface preparation; surgical implant metals; test method; *NBSIR 82-2563*.

titanium; copper; critical current; electrical property; magnetic field; measurement; niobium; superconductor; tin; 21218.

titanium; titanium dioxide; ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; ESD; oxygen; photon stimulated desorption; PSD; synchrotron radiation; 20832.

titanium; ultraviolet photoemission spectroscopy; UPS; hydrogen; methanol; methoxy; oxygen; photon stimulated desorption; PSD; synchrotron radiation; 21296.

titanium; ultraviolet photoemission spectroscopy; UPS; water; hydrogen; oxygen; photon stimulated desorption; PSD; synchrotron radiation; 21005.

titanium alloy; alloy; aluminum alloy; elastic constants; flywheel; iron alloy; mass density; mechanical property; *NSRDS-NBS61, Part V*.

titanium dioxide; ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; ESD; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; 20832.



titanium plate; titanium welds; ultrasonic C-scan; ultrasonic velocity; weld porosity; nondestructive evaluation; *NBSIR 82-2500*.

titanium welds; ultrasonic C-scan; ultrasonic velocity; weld porosity; nondestructive evaluation; titanium plate; *NBSIR 82-2500*.

titration; chemical kinetics solution; kinetic titrimetry; ordinary differential equation solution; parabolic cylinder functions; *20912*.

Ti XVII; wavelengths; V XVIII; Ca XV; Cl XII; energy levels; K XIV; Sc XVI; *21393*.

tobacco smoke; ventilation; air pollution modeling; air quality; contaminant control; standards; *20848*.

toilet dams; wastewater flow reduction; water conservation; faucet aerators; flow reduction; groundwater law; public awareness; *SP624*; 1982 June. 151-154.

tolerances; user requirements; volume-measuring devices; weights; length-measuring devices; liquid-measuring devices; measures; scales; specifications; taximeters; *H44*.

tone-coding; decoder; digital controlled; encoder; law enforcement standard; selective signaling; squelch systems; *20991*.

tool breakage; vibration sensing; drill breakage; Drill-Up; drill wear; time-domain analysis; *NBSIR 82-2590*.

tool failure; tool wear; vibration signatures; automated manufacturing; drill failure prediction; drill wear; finished dimensions; improper drilling; time-domain analysis; *20795*.

toolsmith; computer environments; software; software engineering; software management; software quality; software tools; *SP500-91*.

tool wear; vibration signatures; automated manufacturing; drill failure prediction; drill wear; finished dimensions; improper drilling; time-domain analysis; tool failure; *20795*.

top-down; documentation; documentation standards; FADPUG; software engineering; system decomposition; *SP500-94*; 1982 October. 166-171.

top injection; tracer gas test; bottom injection; multiple injection; smoke candle test; smoke control; stairwell pressurization; *21307*.

topography; x ray; image formation; kinetic study; materials science; synchrotron radiation; *21257*.

topography; x-ray image magnification; multocrystal diffraction; real time; synchrotron; *21259*.

toroidal grating; ultrahigh vacuum; vacuum ultraviolet; grazing incidence; monochromator efficiency; synchrotron radiation; *21069*.

toroidal grating monochromator; vacuum ultraviolet monochromator; far ultraviolet radiation; grating; monochromator; synchrotron radiation; *21079*.

torsional splittings; C-H stretching region; difference-frequency laser; Doppler-limited resolution; ethane; ground state constants; infrared spectrum; low temperature spectrum; *J. Res. 87(3)*: 237-256; 1982 May-June.

torsional vibration; absolute measurement; accelerometer calibration; angular vibration; interferometer; reciprocity calibration; *20967*.

total cholesterol analysis; cholesterol analysis; definitive method; isotope dilution/mass spectrometry; mass spectrometry; stable isotope dilution analysis; statistical analysis; *20796*.

total energy; utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; *SP489, Supplement 1*.

total energy system; absorption chillers; boiler performance; central utility plant; diesel engine performance; engine-generator efficiency; environmental impact; heat recovery; *NBSIR 82-2474*.

total energy systems-economic and engineering analysis; waste heat recovery; absorption chillers; boiler performance; diesel engine performance; engine-generator efficiency; integrated utility system; *NBSIR 82-2483*.

total power radiometer; automated noise measurement system; coaxial noise sources; controller; IEEE 488 Bus; *NBSIR 81-1656*.

total radiated power; dipole moments; electrically small; interference source; leakage; phase measurements; power measurements; radiation pattern; TEM cell; *TN1059*.

toughness; collapse; cracks; defects; failure; fracture mechanics; girth welds; pipeline; plasticity; strength; stress; *21169*.

toxicity; arson; building design; combustion products; fire investigation; fire modeling; fire protection; human behavior; smoke control; smoldering; sprinkler systems; *SP639*.

toxicity; autopsy; biological; carboxyhemoglobin; fatalities; hydrogen cyanide; polymer; *20811*.

toxicity; combustion products; flaming combustion; inhalation; materials; nonflaming combustion; test method; *NBSIR 82-2532*.

toxic substances; laboratory; test data; *SP632*; 1982 March. 79-80.

traceability; absorbed dose; environment; radioactivity; radiopharmaceuticals; standards; *21355*.

traceability; assurance; measurements; radioactivity; radiopharmaceutical; standards; *SP609*; 1982 February. 99-110.

traceability; ATE; calibration; *21028*.

traceability; calibration; definitions; hierarchy of standards; National Bureau of Standards; radiation; standards; *SP609*; 1982 February. 11-17.

traceability; calibration; environment; natural material; radioactivity; radionuclide; standard; *SP609*; 1982 February. 117-127.

traceability; calibration; ionizing radiation; measurement; national standards; quality assurance; standard reference material; *SP609*; 1982 February. 45-58.

traceability; calibration; measurement assurance; measurement services; standards; *SP250, 1982 Edition*.

traceability; calibration instruments; calibrations; calibration techniques; standards; *SP609*; 1982 February. 67-75.

traceability; calibrations; instruments; ionizing radiation; measurements; measurement support system; quality assurance; standards; *SP609*; 1982 February. 3-10.

traceability; calibrations; ionizing radiation; measurements; national standards; quality assurance; secondary standard laboratory; *SP609*.

traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; *SP609*; 1982 February. 171-178.

traceability; calorimetry; dosimeter calibration; dosimetry; electron beams; gamma radiation; quality control; radiation measurement; radiation processing; radiation sterilization; *20974*.

traceability; cobalt-60 gamma radiation; dosimetry; ferrous sulfate dosimetry; high-energy bremsstrahlung; high-energy electrons; measurement assurance; radiation therapy; survey; teletherapy; thermoluminescence dosimetry; *SP609*; 1982 February. 89-97.

traceability; dosimeters; NRC; pilot study; sources; standard; *SP609*; 1982 February. 145-148.

traceability; enforcement; inspections; NRC; radiation measurements; regulations; regulatory guides; *SP609*; 1982 February. 129-133.

traceability; environmental measurements; international quality assurance; national quality assurance; natural-matrix reference materials; radioactivity measurements; radiopharmaceuticals; *20883*.

traceability; type testing; calibrations; codes of practice; ionizing radiation; regulations; standards; *SP609*; 1982 February. 19-27.

traceability; visibility; product assurance; software maintenance; testing; *SP500-94*; 1982 October. 23-29.

traceability; x ray; calibration; instruments; measurements; standards; *SP609*; 1982 February. 59-64.

traceable measurements; ultrasonic reference blocks; ultrasonic transducers; x-ray magnifier; acoustic emission simulator; acoustic emission transducers; nondestructive evaluation; penetrant test block; *21181*.

traceable measurements; visual testing; acoustic emission; calibration; leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; radiography; standards; *21398*.

traceable NDE; visual acuity; acoustic emission; eddy currents; leak rate measurements; liquid penetrants; magnetic particles; neutron radiography; *21166*.

trace analysis; accuracy; high purity materials; instrumental neutron activation analysis; precision; reference materials; standards; *20997*.

trace analysis of solids; two-photon absorption spectroscopy; laser ablation; laser-produced vaporization; laser-solid interaction; plasma production and heating by laser beam; pulsed-dye laser application; resonance ionization spectroscopy; *20922*.

trace element analysis; analytical blank; contamination control; sample handling; sample storage; sampling; *21373*.

trace elements; acidity; acid rain; chemical analysis; conductance; pH; precipitation; rain; reference materials; *NBSIR 82-2581*.

trace elements; chemical blank; contamination control; leachates; leach testing; nuclear waste; trace elements. nuclear waste; *21372*.

trace elements. nuclear waste; trace elements; chemical blank; contamination control; leachates; leach testing; nuclear waste; *21372*.

tracer gas; bombing; fine leak test; gross leak test; helium; hermeticity; *SP400-72*; 1982 April. 281-288.

tracer gas test; bottom injection; multiple injection; smoke candle test; smoke control; stairwell pressurization; top injection; *21307*.

tracking; tuneable; active; antenna; filter; monopole; *20892*.

track maintenance planning; track standards; computer simulation; life



cycle costs; maintenance, track; Simulation Cost Model; *SP640*; 1982 October. 199-215.

track standards; computer simulation; life cycle costs; maintenance, track; Simulation Cost Model; track maintenance planning; *SP640*; 1982 October. 199-215.

tractor model; exporting; governmental regulations; manufacturer; *SP632*; 1982 March. 59-60.

trade; foreign regulations; GATT; notification program; standards code; *21145*.

training; accuracies, comparison of; government careers; in-service training; physics classroom experiments; statistical consulting course; statistics; *20947*.

training; analytical procedures; hazardous waste management; lab procedures; Louisiana; Resource Conservation and Recovery Act; test protocols; *NBS-GCR-81-349*.

training; analytical procedures; hazardous waste management; lab procedures; Mississippi; Resource Conservation and Recovery Act; test protocols; *NBS-GCR-81-353*.

training; analytical procedures; hazardous waste management; lab procedures; Oklahoma; Resource Conservation and Recovery Act; test protocols; *NBS-GCR-81-350*.

training; analytical procedures; hazardous waste management; lab procedures; Pennsylvania; Resource Conservation and Recovery Act; test protocols; *NBS-GCR-81-351*.

training; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; Texas; *NBS-GCR-81-352*.

training; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; *NBS-GCR-81-348*.

training; Virginia; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; *NBS-GCR-81-354*.

training; weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; *SP629*.

train line; contact derailment sensor; g-sensing derailment detector; local derailment; nitinol sensor; on-board failure detection system; overheated bearings; thermal switch sensor; *SP621*; 1982 October. 49-68.

trains; automated NDE; Braking Inspection System (BIS); braking system performance; *SP621*; 1982 October. 91.

trajectories; vibrational spectroscopy; electron-hole pairs; Franck-Condon factors; surface reactions; *21178*.

transactions; annual reports; diffusion in metals; fire; journals; library holdings; NBS Library; NBS periodicals; periodicals; proceedings; serials; standards; *NBSIR 82-2575*.

transducer; pressure; *21020*.

transducer; ultrasonic; acoustic emission; elastic wave; nondestructive evaluation; Rayleigh wave; *21098*.

transfer standard; absolute calibration; absolute quantum yield; actimetry; amplitude stabilized lasers; electrically calibrated radiometers; ferrioxalate actinometer; laser power meter calibration; photon flux; quantum yield; *21045*.

transfer standards; calibration; measurement assurance; measurement assurance programs; reference standards; standard capacitors; standard qualification; *TN1162*.

transfer standards; transition duration; waveform generation; waveform measurements; calibration; reference waveform generators; rise time; time domain measurements; *SP634*; 1982 June. 69-88.

transformation; artificial satellite; Hamiltonian; parallax transformation; third-order solution; *21381*.

transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; *NBSIR 82-2501*.

transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF<sub>6</sub>; space charge; *NBSIR 82-2528*.

transformer oil; cables; dc fields; high voltage; incipient fault; insulation; SF<sub>6</sub>; space charge; *NBSIR 82-2586*.

transient; hot wire; oxygen; pressure temperature; thermal conductivity; *J. Res.* 87(4): 279-310; 1982 July-August.

transient capacitance techniques; deep-level measurements; deep-level transient spectroscopy; defect characterization; lifetime; power-device grade silicon; *NBSIR 82-2552*.

transient digitizer; transient response; waveform recorder; analog-to-digital converter; digital processing; dynamic testing; sine-wave testing; *SP634*; 1982 June. 27-34.

transient dipoles; collision-induced absorption; collision-induced light scattering; far infrared absorption; induced dipole; line shape; rare gas mixtures; spectra; *21173*.

transient effects; ionisation; linear polarization; monochromatic resonance; multiphoton; perturbation theory; radiation; sodium atom; time development; *21075*.

transient electromagnetic fields; wave equations; dyadic Green functions; electromagnetic scattering; integral equations; perfect conductors; *TN1157*.

transient fluid motion; transient heat transfer; compressible fluid motion; convection; finite difference approximation; heat transfer; natural convection; nonlinear convection; numerical integration; *NBSIR 82-1660*.

transient heat transfer; compressible fluid motion; convection; finite difference approximation; heat transfer; natural convection; nonlinear convection; numerical integration; transient fluid motion; *NBSIR 82-1660*.

transient hot wire; liquid; propane; thermal conductivity; *20831*.

transient phenomena; electrical breakdown; high speed photography; Kerr effect; liquid breakdown; nitrobenzene; partial discharges; streamers; *21328*.

transient phenomena; high voltage dividers; partial discharge; *SP628*; 1982 June. 69-79.

transient pipe flow; transient solid motion, pipe flows; computational method, fluid mechanics; drainage piping; *21081*.

transient propagation; arbitrary isotropic media; discontinuity conditions; discontinuous radiation; electromagnetic field constraints; electromagnetic pulse; field jumps; Lorentz transformation; special relativity; surface charge conservation; *21327*.

transient recorder; analog-to-digital converter; digitizer; dynamic testing; effective number of bits; frequency domain; quantizing error; signal-to-noise ratio; time domain; *SP634*; 1982 June. 7-21.

transient recording laboratory; transient surges; electrical transient phenomena; *SP628*; 1982 June. 355-364.

transient response; waveform recorder; analog-to-digital converter; digital processing; dynamic testing; sine-wave testing; transient digitizer; *SP634*; 1982 June. 27-34.

transients; voltage measurements; current measurement; electrical measurements; electromagnetic pulse; fusion; nuclear effects simulation; particle beam technology; pulse power; *SP628*.

transient solid motion, pipe flows; computational method, fluid mechanics; drainage piping; transient pipe flow; *21081*.

transient surges; electrical transient phenomena; transient recording laboratory; *SP628*; 1982 June. 355-364.

transistor; electronics; noise; photon detector; rectifier; solid state devices; *TN1169*.

transition duration; waveform generation; waveform measurements; calibration; reference waveform generators; rise time; time domain measurements; transfer standards; *SP634*; 1982 June. 69-88.

transition matrix; carrier sense multiple access; channel access; load dependent; local area networks; M/M/1/N queue; protocols; relaxation time; sensitivity; slotted aloha; throughput; *SP500-95*; 1982 October. 365-373.

transition metals; amorphous materials; ferromagnetism; magnetization; neutron diffraction; spin waves; *20945*.

transition moments; blue-green laser; effective core potentials; excimer; rare-gas halide; *21309*.

transition moments; diatomic molecules; intensity factor; notation conventions; rotational line strengths; *21274*.

transition moments; tunable lasers; anharmonicity; combination band; high-resolution; molecular spectroscopy; *20924*.

transition probabilities; atomic energy levels; atomic spectra; energy levels; f-values; interstellar molecules; molecular spectra; molecules; oscillator strengths; radio astronomy; spectra; spectroscopy; *21185*.

transition probability assignment; Ca<sub>j</sub>; charge density; electronic spectra; predissociation; *21310*.

transition state; zinc oxide; chemisorption; hydrogen; hydrogen deuterate; kinetic isotope effect; *20971*.

transition temperature; tungsten; beryllium; fixed points; liquid <sup>3</sup>He; superconductivity; temperature; *21063*.

translational spectrum; wave mechanical lineshapes; argon; binary mixtures; collision-induced absorption; potential functions; spectral moments; *20929*.

transmission; treeing; aging; dielectric; distribution; electrical failure;



polyethylene; reflectometry; rf characteristics; 21140.

transmission electron microscope; electron microscope; energy dispersive x-ray spectrometry; image analysis; scanning transmission; selected area electron diffraction; *SP619*; 1982 March. 207-210.

transmittance; weighted ordinate; air mass; ASTM E 424; integrating sphere spectrophotometer; reflectance; selected ordinate; solar absorber materials; solar cover plates; *NBSIR 81-2448*.

transmittance extrema; electro-optic modulation; hydrogenated amorphous silicon; optical transmittance; refractive index; scattering matrix; thin film; *NBSIR 81-1652*.

transparent armor; armor; ballistic protection; ballistic resistant materials; bulletproof glass; glazing materials; 20910.

transpiration; Knudsen effusion; mass spectrometry; slag vaporization; 21282.

transpiration; vaporization; boric oxide; glass; sodium boron; sodium borosilicate; thermodynamics; 21108.

transport; backscattering; experiment; forward scattering; quenching; resonance; sodium; 20953.

transport; bremsstrahlung; cross sections; data base; electron; photon; 21384.

transport; bremsstrahlung; cross sections; elastic scattering; electron-impact ionization; electrons; photons; stopping power; *NBSIR 82-2572*.

transport; conductivity; electrical; impedance; polyacetylene; 20853.

transport; diffusion; drift velocity; electrons; excitation; nitrogen; numerical calculation; 21002.

transport; velocity; water; equation; flow; horizontal; motion; partially-filled pipe; slope; solid; stream-depth; surge; *NBSIR 81-2450*.

transportable computer software; ANSI FORTRAN; computer independent; double precision; general-purpose computer program; installation of OMNITAB 80; named common blocks; OMNITAB 80; overlay; segmentation; system parameters; *TN1163*.

transportation systems; bridges; diagnostic systems; failure; failure detection systems; fracture; fracture control; ground transportation; motor carriers; pipelines; rail structures; rail vehicles; reliability; *SP621*.

transport coefficient; transport properties; Boltzmann equation; collision integral; kinetic theory; perturbation theory; 21197.

transport mechanisms; transport phenomena; wall friction; building pipe drains; low water usage devices; pitch of the pipe; plumbing drainage system; plumbing fixtures; *SP624*; 1982 June. 293-326.

transport phenomena; wall friction; building pipe drains; low water usage devices; pitch of the pipe; plumbing drainage system; plumbing fixtures; transport mechanisms; *SP624*; 1982 June. 293-326.

transport properties; activity coefficients; aqueous; compilation; conductivity; electrolytes; enthalpy; Gibbs energy; osmotic coefficients; potassium hydroxide; solutions; thermodynamic properties; *NBSIR 81-2356*.

transport properties; Boltzmann equation; collision integral; kinetic theory; perturbation theory; transport coefficient; 21197.

transport standards; automatic test equipment; calibration; calibration traceability; dynamic standards; 21025.

transverse electromagnetic cells; buried electromagnetic enclosures; electromagnetic compatibility measurements (EMC); low-Q chambers; reverberation chambers; 21061.

transverse electromagnetic cells; electromagnetic radiated emissions measurements; open-field site; 21062.

transverse isotropy; beam on elastic foundation; continuum mechanics; core fibril; elasticity; flow-induced crystallization; mathematical modeling; polyethylene; polymer fiber; polymer physics; simple beam theory; 21175.

treatment planning; dosimetry; electrons; Monte Carlo; point-monodirectional beams; superposition; *NBSIR 82-2451*.

treeing; aging; dielectric; distribution; electrical failure; polyethylene; reflectometry; rf characteristics; transmission; 21140.

tree topology; algorithm; capacity assignment; computer communication network; *SP500-95*; 1982 October. 173-182.

triangulations; adaptive meshes; eigenvalues; elliptic equations; finite elements; multi-level iterations; 20823.

tribology; wear; wear debris analysis; diagnostics; ferrography; health monitoring; *SP640*; 1982 October. 466-475.

tributyltin methacrylate; ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); 20955.

tridentate ligand; azometallocycle; benzotriazoleanion; copper complex; corrosion inhibitor; crystal structure; single crystal x-ray diffraction; 21297.

triethyl phosphate; dimethyl sulfoxide; dosimetry; dye dosimetry; electron beam; gamma radiation; liquid dye solution; polar solvents; radiation processing; radiochromic dyes; radiolysis; 20902.

trifluoroethylene copolymer; vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; 21392.

triorganotin compounds; biocides; complexation; diorganotin compounds; element-specific detection; graphite furnace atomic absorption; high-pressure liquid chromatography; ion exchange; leaching; nanogram sensitivity; organotin cations; speciation; 21272.

triphenylmethyl radical; dosimetry dyes; electron spin resonance; ESR; free radicals; gamma radiation; hexa (hydroxyethyl) pararosiline; leucocyanide dyes; nylon; polymer films; polyvinyl butyral; radiation processing; radiochromic dyes; 20905.

triple backing; handcuffs; *U.S. Patent 4,314,466*.

triple point; zinc point; aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; *SP260-77*.

TRIS; tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; 20930.

Tri-Services Committee; building materials; building technology; construction; Department of Defense; 21039.

tris(hydroxymethyl)aminoethane; adiabatic calorimetry; calorimetry; enthalpy; glass; heat; hydrofluoric acid calorimetry; platinum solution calorimetry; quartz; quartz thermometer; solution calorimetry; sulfuric acid; THAM; TRIS; 20930.

tritiated water standards; tritiated water standards, half life; tritiated water standards, preparation of; tritiated water standards, use of; 21336.

tritiated water standards, half life; tritiated water standards, preparation of; tritiated water standards, use of; tritiated water standards, 21336.

tritiated water standards, preparation of; tritiated water standards, use of; tritiated water standards; tritiated water standards, half life; 21336.

tritiated water standards, use of; tritiated water standards; tritiated water standards, half life; tritiated water standards, preparation of; 21336.

tritide; vibration spectra; defect; isotope; metal hydride; neutron scattering; niobium hydride; 20948.

Trombe Wall; ASHRAE Standard; asymmetric heating; collector/storage wall; comfort envelope; comfort zone; mean radiant temperature; operative temperature; passive solar; temperature drifts; thermal comfort condition; *NBSIR 81-2393*.

truck maintenance aids; automated test equipment; diagnostics; technology in truck maintenance; *SP621*; 1982 October. 201-211.

truck-mounted; CCVT; compact; field calibration; high accuracy; modular capacitive divider; portable system; 21287.

trunk; WIN; analytical; capacity planning; central server; disk; main memory contention; modeling; packet switch; performance evaluation; simulation; *SP500-95*; 1982 October. 97-106.

tunable; dye laser; mode-locked; picosecond; pulse emission; streak-camera; 21348.

tunable lasers; anharmonicity; combination band; high-resolution; molecular spectroscopy; transition moments; 20924.

tunable; active; antenna; filter; monopole; tracking; 20892.

tunable laser; frequency scanned laser; rapid frequency scanning; ring dye laser; single frequency dye laser; 20791.

tungsten; Auger spectroscopy; convection; gallium-tin alloys; levitation calorimetry; segregation; specific heat; surface tension; thermophysical properties; *NBSIR 82-2560*.

tungsten; beryllium; fixed points; liquid <sup>3</sup>He; superconductivity; temperature; transition temperature; 21063.

tungsten; beryllium; fixed points; superconductivity; superfluidity; 21219.

tungsten; melting; normal spectral emittance; pulse heating; radiance temperature; 21227.

tungsten; ytterbium; barium; dysprosium; energy levels; erbium; gadolinium; neodymium; samarium; spectrum; tantalum; 20845.



tunnel diode; tunnel diode oscillator; LC oscillator; oscillator sensor; pressure; pulsed oscillator; pulsed sensor; temperature; 21064.  
 tunnel diode oscillator; LC oscillator; oscillator sensor; pressure; pulsed oscillator; pulsed sensor; temperature; tunnel diode; 21064.  
 tunnel diode oscillators; low-temperature gases; noise thermometry; nuclear orientation thermometry; superconductors; temperature fixed points; thermodynamic temperature; thermometry; 21018.  
 tunneling; ac Josephson effect; dc Josephson effect; Josephson junctions; superconductivity; supercurrent; 21316.  
 tunneling;  $\text{AuAl}_2$ ; energy gap; superconductivity; 21351.  
 tunneling; hydrogen in metals; impurities; inelastic structure factor; neutron spectroscopy; niobium; 20941.  
 tunnel states; deuterated; methyl group; neutron scattering; nitromethane; reorientation; 20895.  
 turbulence; buoyancy; cross-correlation; diffusion flames; entrainment; heat flux; radiation; *NBSIR 82-2473*.  
 turbulence; ceilings; fire models; fire plumes; heat transfer; radiation; *NBS-GCR-81-304*.  
 two-Coulomb-center problem; highly excited states of  $E(\text{Zr}_2)$  system; molecular energy splitting; 21376.  
 two-dimensional arrays; wafer map; computer program; correlation coefficient; outlier; process validation wafer; statistical analysis; *NBSIR 82-2492*.  
 two-dimensional electron gas; fine-structure constant; Hall effect; Landau levels; resistance standard; silicon MOSFETs; 21220.  
 two-dimensional systems;  $\text{C}_{60}$ ; inelastic neutron scattering; intercalated systems; lattice dynamics; phonons; 20949.  
 two-photon absorption spectroscopy; laser ablation; laser-produced vaporization; laser-solid interaction; plasma production and heating by laser beam; pulsed-dye laser application; resonance ionization spectroscopy; trace analysis of solids; 20922.  
 two photons; energy transfer; flames; ionization; multiphoton; optogalvanic; 21132.  
 two-stage thermostat; annual efficiency; household heaters and furnace test procedures; hydraulic thermostat control; modulating control gas-fueled; *NBSIR 82-2497*.  
 type testing; calibrations; codes of practice; ionizing radiation; regulations; standards; traceability; *SP609*; 1982 February. 19-27.

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ultra-black coating; electroless nickel plating; nickel-phosphorus alloy; *U.S. Patent 4,361,630*.  
 ultra high molecular weight; creep; fatigue; morphology; polyethylene; stress-crack resistance; stress-relaxation; *NBSIR 82-2493*.  
 ultrahigh vacuum; vacuum ultraviolet; grazing incidence; monochromator efficiency; synchrotron radiation; toroidal grating; 21069.  
 ultrasonic; acoustic emission; elastic wave; nondestructive evaluation; Rayleigh wave; transducer; 21098.  
 ultrasonic; echo-ranging transducer; industrial robots; robots; safety; sensors; 20977.  
 ultrasonic baths; asbestos fiber; asbestos reference suspension; fiber loading; filters; *SP619*; 1982 March. 68-76.  
 ultrasonic C-scan; ultrasonic velocity; weld porosity; nondestructive evaluation; titanium plate; titanium welds; *NBSIR 82-2500*.  
 ultrasonic reference blocks; ultrasonic transducers; x-ray magnifier; acoustic emission simulator; acoustic emission transducers; nondestructive evaluation; penetrant test block; traceable measurements; 21181.  
 ultrasonics; bibliography; physical acoustics; summary; *NBSIR 82-2529*.  
 ultrasonics; interface; measurement; melting; metals; process control; pulse-echo technique; signal processing; solidification; 21362.  
 ultrasonics; visual-optical; acoustic emission; eddy currents; liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; radiography; tire inspection; 20957.  
 ultrasonics; x-ray diffraction; Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; residual stress; stress measurements; 20926.  
 ultrasonics; x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; residual stress; standards; stress measurement; terminology; 21344.  
 ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics;

nondestructive evaluation; nondestructive testing; 21223.  
 ultrasonic scattering; ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; 21236.  
 ultrasonic scattering; ultrasonic waves; acoustic waves; elastic anisotropy; nondestructive evaluation; stainless steel; 21224.  
 ultrasonic testing; elastic anisotropy; flaw detection; horizontally polarized shear waves; stainless steel; 21253.  
 ultrasonic testing; ultrasonic transducers; ultrasonic waves; weld evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; 21242.  
 ultrasonic testing; ultrasonic transducers; ultrasonic waves; welding evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; 21235.  
 ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; 21223.  
 ultrasonic transducers; ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; 21236.  
 ultrasonic transducers; ultrasonic waves; weld evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; 21242.  
 ultrasonic transducers; ultrasonic waves; welding evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; 21235.  
 ultrasonic transducers; x-ray magnifier; acoustic emission simulator; acoustic emission transducers; nondestructive evaluation; penetrant test block; traceable measurements; ultrasonic reference blocks; 21181.  
 ultrasonic velocity; weld porosity; nondestructive evaluation; titanium plate; titanium welds; ultrasonic C-scan; *NBSIR 82-2500*.  
 ultrasonic wave; Young's modulus; boron-aluminum; elastic constants; glass-epoxy; graphite-epoxy; internal friction; shear modulus; sound velocity; 20868.  
 ultrasonic waves; acoustic waves; elastic anisotropy; nondestructive evaluation; stainless steel; ultrasonic scattering; 21224.  
 ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; 21223.  
 ultrasonic waves; acoustic waves; fitness-for-service; fracture mechanics; nondestructive evaluation; nondestructive testing; ultrasonic scattering; ultrasonic transducers; 21236.  
 ultrasonic waves; variational method; acoustic waves; cracks; finite element method; nondestructive evaluation; scattering; 21229.  
 ultrasonic waves; weld evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; 21242.  
 ultrasonic waves; welding evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; 21235.  
 ultratrace analysis; x-ray spectrometry; cation exchange resin-loaded filters; environmental samples; 21364.  
 ultraviolet;  $\text{Br}(\text{P}_{1/2})$ ;  $\text{I}(\text{P}_{1/2})$ ; laser; photofragmentation; photolysis; 20785.  
 ultraviolet; vibrational spectra; visible; electronic spectra; infrared; microwave; molecular spectroscopy; rotational spectra; 21388.  
 ultraviolet; yttrium; energy level; ionization energy; spark; spectrum; 21240.  
 ultraviolet absorbance; weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; 20955.  
 ultraviolet detector; ultraviolet spectrograph; plasma diagnostics; 21046.  
 ultraviolet photoemission spectroscopy; UPS; electron stimulated desorption; ESD; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; titanium dioxide; 20832.  
 ultraviolet photoemission spectroscopy; UPS; hydrogen; methanol; methoxy; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; 21296.  
 ultraviolet photoemission spectroscopy; UPS; water; hydrogen; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; 21005.  
 ultraviolet reflectance; absorption coefficient; black paint; deuterium lamp; silicon photodiode; specular reflectance; 20989.



ultraviolet spectra; flare stars; late-type stars; stellar chromospheres; stellar coronae; 21405.

ultraviolet spectra; late-type stars; stellar atmospheres; stellar chromospheres; stellar coronae; 21122.

ultraviolet, spectra; planets, abundances; planets, atmospheres; planets, Jupiter; planets, Saturn; planets, spectra; 21076.

ultraviolet, spectra; stars, atmospheres; stars, chromospheres; stars, late-type; 21070.

ultraviolet, spectra; stars, Ba II; stars, individual; stars, late-type; stars, white dwarfs; stars, winds; 20998.

ultraviolet, spectra; stars, binaries; stars, chromospheres; stars, individual; stars, late-type; 20937.

ultraviolet spectrograph; plasma diagnostics; ultraviolet detector; 21046.

ultraviolet spectrum; late-type stars; stars, individual; stellar atmospheres; stellar chromospheres; 20816.

unbalanced pricing; workload forecasting; basic agreement solicitations; evaluation of system life costs; teleprocessing services procurements; SP500-95; 1982 October. 27-33.

uncertainties in gamma-ray measurements; calibration of gamma-ray detector efficiencies; emission-rate measurements; gamma-ray spectrometry; germanium-detector efficiencies; long-lived-mixed radionuclide standard; 20874.

uncertainty; collector rating; incident angle modifier; measurement; solar collector; standards; thermal performance; 21387.

uncertainty; IC photomask; linear calibration curve; line-spacing; linewidth; measurement assurance; photomask; SRM; statistical control of measurement process; statistical methods; tests for systematic error; TN1164.

uncertainty limits; calibration; curve-fitting; statistics; 20800.

uncertainty relations; vector potential; Bohm-Aharonov; electrical transformer; interference; quantum mechanics; 20794.

undercooling; amorphous; cooling rate; crystalline; dendrites; interfaces; microcrystalline; nucleation; recalcence; solidification; 21090.

underground; alloys; containers; corrosion; corrosion data; geothermal brines; metals; nuclear waste; NBSIR 81-2409.

underground; alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; NBSIR 82-2509.

underground corrosion; vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; Desulfovibrio; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; 21326.

unglazed collector; ASHRAE Standard 96-1980; BSE; collector efficiency; NBSIR 82-2522.

uniform documentation standards; user guide documentation standards; user involvement; documentation categories; documentation elements; SP500-94; 1982 October. 43-45.

unimolecular dissociation rates; CF<sub>3</sub>HCl (chlorodifluoromethane); induction times; infrared laser; intensity dependence in infrared photochemistry; laser chemistry; laser excited fluorescence; multiphoton dissociation; 21342.

unimolecular reactions; vibrational relaxation; energy transfer; intramolecular dynamics; laser-excited fluorescence; laser-induced chemistry; multiphoton processes; 21341.

United Kingdom; water conservation practices; demand management; supply management; Thames Water Authority; SP624; 1982 June. 367-372.

United States; accrediting laboratories; international; NVLAP system; SP632; 1982 March. 92-98.

unit pricing; Weighmaster Law; basic weights and measures law; method of sale of commodities; open dating; packaging and labeling; registration of servicepersons; H130, 1983 Edition.

units; data reporting; detection limit; environmental; lower limit of detection (LLD); measurements; minimum detectable concentration (MDC); radiation; random uncertainty; significant figures; systematic uncertainty; 20888.

UNIVAC; disk I/O; hardware monitoring; performance measurement; Shuttle Mission Simulator; SP500-95; 1982 October. 217-230.

UNIVAC systems; modeling; performance evaluation; simulation; SP500-95; 1982 October. 231-257.

UNIX; validation; performance prediction; queueing theory; SP500-95; 1982 October. 205-211.

unshielded; chronoamperometry; coefficient; diffusion; electrodes; examination; planar; stationary; 21361.

unstable; nonlinear; relaxation; supercooling; Suzuki's scaling; time-dependent growth rate; 21399.

unstable molecules; bond distance; boron chloride; diode lasers; Dunham coefficients; infrared; spectra; 20817.

unsteady; water tunnel; waves; drag; oscillatory flow; phase dependent; ripple; sand; sea bed; stress; time dependent; 21332.

unsteady flow; building drainage; computer model; surge attenuation; NBSIR 82-2478.

unsteady flow; computer based model; drainage; solid transport; BSS139.

unsteady flow; vortex shedding; computer simulation; external aerodynamics; fluid dynamics; mathematical modeling; numerical methods; 21044.

updated information; environment; laboratory accreditation; SP632; 1982 March. 36-39.

upholstered furniture; chairs; compartment fires; fire tests; flammability; furnishings; 21092.

upholstered furniture; cigarettes; fabrics; flammability; ignition; polyester batting; polyurethane foam; self-extinguishment; smoldering; test development; textiles; 21128.

UPS; electron stimulated desorption; ESD; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; titanium dioxide; ultraviolet photoemission spectroscopy; 20832.

UPS; hydrogen; methanol; methoxy; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; 21296.

UPS; water; hydrogen; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; 21005.

uranium; hydride; hydrogen; microscopy; orthorhombic; surfaces; 21021.

uranium-235; ionization chamber; mass; neutron beam design; neutron fission; 20814.

uranium-235; 14 MeV neutron energy; associated particle; fission cross section; 20861.

urban particulates; vegetative burning; air pollution; biogenic/fossil carbon impact; field and slash burning; Portland aerosol characterization study; radiocarbon; residential wood burning; 20964.

urban solar application; daylighting; glazing transmission; shading algorithms; solar access; solar radiation data; NBSIR 82-2498.

urban water resource planning; water conservation; public education programs; SP624; 1982 June. 179-190.

U.S. Army; long life; reduced maintenance; silicone brake fluid; SP640; 1982 October. 162-169.

used oil; waste oil; lubricants; oil recycling; petroleum; pollution control; reclaiming; re-refining; 21383.

used oil recycling; additive response; lubricating oil bench tests; lubricating oil; lubricating oil analysis; lubricating testing; petroleum; petroleum testing; recycled oil; re-refining; 21397.

useful life; cable assembly; fatigue; stability; storage coil; superconductor; 21214.

user experience; documentation standards; software compatibility; SP500-94; 1982 October. 8-15.

user guide documentation standards; user involvement; documentation categories; documentation elements; uniform documentation standards; SP500-94; 1982 October. 43-45.

user information; users manual; quality control; quality control tool; system verification; SP500-94; 1982 October. 256-264.

user involvement; documentation categories; documentation elements; uniform documentation standards; user guide documentation standards; SP500-94; 1982 October. 43-45.

user level workloads; Ethernet; Ethernet performance; Ethernet simulation; higher level protocols; interactive program development; layered architecture; time-sharing; SP500-95; 1982 October. 375-388.

user manuals; automated data systems; SP500-94; 1982 October. 225-229.

user requirements; volume-measuring devices; weights; length-measuring devices; liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; H44.

user service reporting system (USRS); ADP effectiveness; computer performance evaluation (CPE); computer performance management (CPM); service levels; NBS-GCR-82-382.

user's groups; verbal documentation; beginning computer users; documentation; hardware systems documentation; large computer manufacturers; microcomputers; periodical literature and documentation; software documentation; SP500-94; 1982 October. 174-179.

users manual; quality control; quality control tool; system verification;



user information; *SP500-94*; 1982 October. 256-264.  
 USP reference standard; x-ray diffraction; analgesic; anticonvulsant; azepine ring; carbamazepine; crystal structure; molecular structure; 21298.  
 U.S. Water Resources Council; water conservation; water resource management; *SP624*; 1982 June. 91-102.  
 utility systems; abstracted reports and articles; coal-fired MIUS; comparison studies; concept background of MIUS; conservation of energy; energy analysis; HUD/MIUS Program; HVAC systems; performance analysis; solid waste; total energy; *SP489, Supplement 1*.  
 UV light; hermeticity; hybrid; leak test; methanol; silicone coating; *SP400-72*; 1982 April. 271-274.  
 UV spectral measurements; atmospheric attenuation; atmospheric ozone; optical radiation measurements; radiometry; solar radiation; spectroradiometry; *TN910-5*.  
 U-235 fission cross section; absolute fission cross section; neutron detector; neutron flux monitor; neutron standards; 21135.

## V

vacancies; x-ray emission; electron production; multiple ionization; 21261.  
 vacuum; methyl viologen; nonaqueous; thin layer spectroelectrochemistry; 20872.  
 vacuum ultraviolet; charge recombination; cyclopentane; photofragmentation; photoionization; quantum yields; radiation chemistry; 21243.  
 vacuum ultraviolet; grazing incidence; monochromator efficiency; synchrotron radiation; toroidal grating; ultrahigh vacuum; 21069.  
 vacuum ultraviolet; x rays; atomic spectra; atomic wavelengths; He-like ions; isoelectronic sequence; spectra series; 20803.  
 vacuum ultraviolet; yttrium; ion; laser-produced plasma; spectrum; strontium; 21356.  
 vacuum ultraviolet; yttrium; zirconium; molybdenum; niobium; spectra; strontium; 21179.  
 vacuum ultraviolet monochromator; far ultraviolet radiation; grating; monochromator; synchrotron radiation; toroidal grating monochromator; 21079.  
 valence states; Yukawa potential; bandgap narrowing; Bargmann potential; conduction states; donors; effective mass; energy dispersion; impurities; silicon; 20855.  
 validation; assertions; data abstractions; implementation; PL/I; specifications; 20943.  
 validation; automated software tools; software lifecycle; software testing; software verification; test coverage; test data generation; *SP500-98*.  
 validation; performance prediction; queueing theory; UNIX; *SP500-95*; 1982 October. 205-211.  
 validation; V,V&T techniques; V,V&T tools; automated software tools; dynamic analysis; formal analysis; software testing; software verification; static analysis; test coverage; *SP500-93*.  
 valve; air conditioning; building systems; computer; control; heat exchanger; modeling; monitoring; research; steam; thermal response; 21048.  
 valve; database; data collection; failure data; inservice data; inservice inspection; mechanical component; nondestructive evaluation; piping; pressure vessel; pump; reliability; risk analysis; 21176.  
 Van der Waals; damped dispersion; energy curve; polarizabilities; 20788.  
 vapor crack detection; ceramic crack detection; ceramic cracks; ceramic fissures; crack detection; fissure detection; fissures; *SP400-72*; 1982 April. 201-211.  
 vaporization; boric oxide; glass; sodium boron; sodium borosilicate; thermodynamics; transpiration; 21108.  
 vapor-liquid equilibrium; activity coefficients; benzene; cyclohexane; evaluation procedures; excess Gibbs function; *JPCRD 11(4)*: 1099-1127; 1982.  
 vapor-liquid equilibrium; vapor pressure; volume change of mixing; equations of state; heat of mixing; liquid density; mixtures; second virial coefficients; *JPCRD 11(3)*: 941-951; 1982.  
 vapor phase; virial coefficients; Burnett method; equation of state; ethylene; helium; saturation density; 21228.  
 vapor phase reaction; carbocyclic compound; cyclic sulfide; ozone; *U.S. Patent 4,327,233*.  
 vapor pressure; enthalpy; equation of state; heavy water; Helmholtz function; *PVT*; specific heats; speed of sound; thermodynamic

properties; *JPCRD 11(1)*: 1-14; 1982.  
 vapor pressure; volume change of mixing; equations of state; heat of mixing; liquid density; mixtures; second virial coefficients; vapor-liquid equilibrium; *JPCRD 11(3)*: 941-951; 1982.  
 vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; *Monogr. 169*.  
 vapor pressures; velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; *Monogr. 170*.  
 vapor pressures; virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; *TN1051*.  
 variational method; acoustic waves; cracks; finite element method; nondestructive evaluation; scattering; ultrasonic waves; 21229.  
 variational method; elastic waves; flaws; nondestructive evaluation; nondestructive testing; scattering; 21239.  
 variational method; Green's function; input impedance; probe antenna; radiation resistance; rectangular coaxial transmission line; TEM cell; *TN1054*.  
 varnishes; adiabatic calorimetry; automated calorimetry; cross-linked polymer; differential scanning calorimetry; heat capacity; moisture effect; phenolic resin; specific heat; thermosetting polymers; 21032.  
 VDMOS; drain-source resistance; electron devices; gamma radiation effects; MOSFETs; MOS power transistors; neutron radiation effects; power transistors; radiation effects; semiconductor devices; 21000.  
 vector potential; Bohm-Aharonov; electrical transformer; interference; quantum mechanics; uncertainty relations; 20794.  
 vector processing; Amdahl's Law; benchmarking; computing environment; large-scale scientific computing; parallel processing; scientific workload; *SP500-95*; 1982 October. 121-126.  
 vegetative burning; air pollution; biogenic/fossil carbon impact; field and slash burning; Portland aerosol characterization study; radiocarbon; residential wood burning; urban particulates; 20964.  
 vehicle; water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; *TN1150*.  
 vehicle inspections; highway transportation; safety; *SP621*; 1982 October. 177-185.  
 vehicular rust; battery-acid corrosion; metal coating; polymer coating; rust prevention; *SP640*; 1982 October. 275-289.  
 velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; propane; specific heats; vapor pressures; *Monogr. 170*.  
 velocities of sound; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; normal butane; orthobaric densities; specific heats; vapor pressures; *Monogr. 169*.  
 velocity; water; equation; flow; horizontal; motion; partially-filled pipe; slope; solid; stream-depth; surge; transport; *NBSIR 81-2450*.  
 velocity algorithm; building controls; digital-to-pneumatic conversion; direct digital control; energy controls; HVAC system; microprocessor control; pneumatic control system; 20995.  
 velocity autocorrelation; distribution functions; hard rods; molecular dynamics; non-ergodic; relaxation; 21283.  
 velocity gradients; higher-order moments; hot-wire anemometry; lognormal; small-scale turbulence; 21278.  
 velocity of sound; acoustical measurements; acoustic resonator; adsorption; nitrogen; physical acoustics; precondensation; propane; sorption; speed of sound; 21230.  
 velocity of sound; virial coefficients; equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; speed of sound; thermodynamic properties; 21208.  
 ventilation; air conditioning; air distribution; building systems; computer; control; modeling; office building; thermal response; 21047.  
 ventilation; air pollution modeling; air quality; contaminant control;



standards; tobacco smoke; 20848.

ventilation; fires; fire size; fuels; heat of combustion; heat release rate; plastics; *NBS-GCR-82-395*.

ventilation systems; ceiling systems; hazard analysis; hospitals; interstitial space; mattresses; smoke control; smoke exhaust; smoke movement; *NBSIR 81-2444*.

verbal documentation; beginning computer users; documentation; hardware systems documentation; large computer manufacturers; microcomputers; periodical literature and documentation; software documentation; user's groups; *SP500-94*; 1982 October. 174-179.

verification and testing; V,V&T technique and tools; environment; software development and maintenance; software validation; standards; *NBSIR 82-2482*.

VHF-UHF frequency range; wavelength-size scalar horns; antenna directivity pattern; antenna measurements; calculated radiation parameters; polarization; standard antennas; 21222.

vibration; acoustic emission; hermeticity; hybrid microelectronics; hybrid packages; microelectronic packaging; thermal shock; *SP400-70*.

vibration; balancing; diagnostics; faults; jet engines; monitoring; overhaul; productivity; *SP640*; 1982 October. 115-129.

vibration; energy transfer; hydrogen halide; molecular relaxation; *JPCRD 11(3)*: 953-996; 1982.

vibrational analysis; hexagonal urea lattice; inclusion compounds; microanalysis; normal alkanes; Raman microprobe; Raman spectroscopy; 20996.

vibrational polarizabilities; atomic polarization; dipole polarizabilities; infrared intensities; molecular polarizabilities; *JPCRD 11(1)*: 119-133; 1982.

vibrational relaxation; energy transfer; intramolecular dynamics; laser-excited fluorescence; laser-induced chemistry; multiphoton processes; unimolecular reactions; 21341.

vibrational relaxation; hydrocarbons; intramolecular relaxation; laser; 20920.

vibrational spectra; bond distances; carbon diselenide; infrared; molecular structure; spectroscopy; 20801.

vibrational spectra; deuterium on diamond; diamond(111) 1×1; EELS; electron energy loss spectroscopy; hydrogen on diamond; semiconducting diamond; surface reconstruction; surface states; 21288.

vibrational spectra; visible; electronic spectra; infrared; microwave; molecular spectroscopy; rotational spectra; ultraviolet; 21388.

vibrational spectroscopy; chemisorption; hydrogen; neutron inelastic scattering; Raney nickel; 21295.

vibrational spectroscopy; electron-hole pairs; Franck-Condon factors; surface reactions; trajectories; 21178.

vibrational spectroscopy; sticking; surface reaction dynamics; 21286.

vibration control; vibration isolation; active vibration control; Michelson interferometer; optical path-length correction; phase comparator; real-time control; 21403.

vibration isolation; active vibration control; Michelson interferometer; optical path-length correction; phase comparator; real-time control; vibration control; 21403.

vibration product states; flowing afterglow; fluoride ion; infrared chemiluminescence; ion-molecule reactions; 20784.

vibration sensing; drill breakage; Drill-Up; drill wear; time-domain analysis; tool breakage; *NBSIR 82-2590*.

vibration signatures; automated manufacturing; drill failure prediction; drill wear; finished dimensions; improper drilling; time-domain analysis; tool failure; tool wear; 20795.

vibration spectra; defect; isotope; metal hydride; neutron scattering; niobium hydride; tritide; 20948.

view out; window; window management; control; daylight; energy balance; natural ventilation; psychological needs; 21043.

vinylidene; energetics; excited states; kinetics; methylene; radicals; 20783.

vinylidene fluoride copolymer; crystal forms; crystalline transformation; Curie temperature; ferroelectric; molecular conformation; piezoelectricity; poling; polytrifluoroethylene; pyroelectricity; trifluoroethylene copolymer; 21392.

vinylidene fluoride; charge transport; copolymer; electrical properties; piezoelectricity; poling; pyroelectricity; tetrafluoroethylene; 20840.

Virginia; analytical procedures; hazardous waste management; lab procedures; Resource Conservation and Recovery Act; test protocols; training; *NBS-GCR-81-354*.

virial coefficients; Burnett method; equation of state; ethylene; helium; saturation density; vapor phase; 21228.

virial coefficients; densities; dielectric constants; enthalpies; entropies; equation of state; fugacities; internal energies; isobars; isobutane; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; sound velocities; specific heats; vapor pressures; *TN1051*.

virial coefficients; equation of state; ethylene; ideal gas heat capacity; physical acoustics; propane; relaxation; specific heat; speed of sound; thermodynamic properties; velocity of sound; 21208.

viscosity; computer simulation; fluid structure; nonequilibrium molecular dynamics; normal pressure effects; orientational distortion; radial distribution function; shear; soft sphere fluid; 21237.

viscosity; corresponding states; Enskog model; equation of state; hard spheres; propane; 21225.

visibility; correlation; fire tests; full-scale; smoke; smoke density chamber; optical density; test methods; *NBSIR 82-2508*.

visibility; product assurance; software maintenance; testing; traceability; *SP500-94*; 1982 October. 23-29.

visible; electronic spectra; infrared; microwave; molecular spectroscopy; rotational spectra; ultraviolet; vibrational spectra; 21388.

vision; vision systems; artificial intelligence; automation; computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; *NBSIR 82-2582*.

vision systems; artificial intelligence; automation; computational; computer perception; computer vision; forecasting; image understanding; industrial vision systems; pattern recognition; scene analysis; vision; *NBSIR 82-2582*.

visual acuity; acoustic emission; eddy currents; leak rate measurements; liquid penetrants; magnetic particles; neutron radiography; traceable NDE; 21166.

visual alerting; warning; communication; design issues; hazard; pictograms; pictorial; safety; signs; standards; symbols; *BSS141*.

visual-optical; acoustic emission; eddy currents; liquid penetrants; magnetic particles; microwaves; nondestructive evaluation; radiography; tire inspection; ultrasonics; 20957.

visual testing; acoustic emission; calibration; leak rate measurements; liquid penetrants; magnetic particles; nondestructive evaluation; radiography; standards; traceable measurements; 21398.

vitamins; food matrices; methods of measurement; nutrients; SRM's; stability; *SP635*.

vivianite; anaerobic corrosion; cathodic depolarization; corrosion rates; *Desulfobivrio*; film formation; hydrogen sulfide; iron phosphide; mechanism; microbial corrosion; overview; sulfate reducing bacteria; underground corrosion; 21326.

VMAP; graphical presentation; IBM VM/SP; performance evaluation; performance measurement; performance prediction; *SP500-95*; 1982 October. 331-359.

VM monitor; VM performance analysis; CPU utilization; queue drops; *SP500-95*; 1982 October. 321-329.

VM performance analysis; CPU utilization; queue drops; VM monitor; *SP500-95*; 1982 October. 321-329.

voice message traffic; digital communications equipment; digital techniques; equipment standards; law enforcement; mobile digital terminals; *NBS-GCR-81-356*.

Voigt function; lineshape; radiative transfer; spectral line formation; stellar atmospheres; 21148.

voltage; clamping; diode recovery; high power measurements; high voltage; overshoot; power semiconductors; reverse-bias second breakdown; testing; 20849.

voltage determinations; deuteron current; dielectric; neutron; proton current; pulsed generators; pulsed power; *SP628*; 1982 June. 104-117.

voltage measurement; comparative measurements; design; dividers; impulse measuring systems; resistor dividers; response time; *SP628*; 1982 June. 34-45.

voltage measurements; current measurement; electrical measurements; electromagnetic pulse; fusion; nuclear effects simulation; particle beam technology; pulse power; transients; *SP628*.

voltage monitor; insulated transmission lines; magnetic insulation; multiterawatt accelerators; particle beam fusion; peak gap voltage; *SP628*; 1982 June. 80-86.

voltage monitor; waterline voltage monitor; capacity divider; high voltage divider; pulse voltage monitor; *SP628*; 1982 June. 20-25.

voltage probes; calibrations; capacitance-current; dielectric; high voltage pulser; pulse generators; *SP628*; 1982 June. 59-68.

volume; volumetric properties; apparent molal volume; aqueous sodium chloride solutions; compressibility; density; equation of



- state; expansivity; Pitzer's equations; *PVT*; *JPCRD 11(1)*: 15-81; 1982.
- volume; volumetric test measures; water calibration; accountability tank; calibration; differential pressure; *TN1158*.
- volume calibration; calibration accuracy; laser calibration; LNG ship tanks; photogrammetry; *NBSIR 81-1655*.
- volume change of mixing; benzene; cyclohexane; evaluation procedures; excess volume; *JPCRD 11(4)*: 1153-1171; 1982.
- volume change of mixing; equations of state; heat of mixing; liquid density; mixtures; second virial coefficients; vapor-liquid equilibrium; vapor pressure; *JPCRD 11(3)*: 941-951; 1982.
- volume-measuring devices; weights; length-measuring devices; liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; user requirements; *H44*.
- volumetric efficiency; waste removal; water closets; residential water use; sanitary performance; surface cleansing; test methods; *SP624*; 1982 June. 273-280.
- volumetric properties; apparent molal volume; aqueous sodium chloride solutions; compressibility; density; equation of state; expansivity; Pitzer's equations; *PVT*; volume; *JPCRD 11(1)*: 15-81; 1982.
- volumetric test measures; water calibration; accountability tank; calibration; differential pressure; volume; *TN1158*.
- volunteer test subjects; chain saw kickback motion; displacement measurements; kickback energy; optoelectronic measurement system; simulated kickback motion; *NBSIR 82-2559*.
- vortex shedding; computer simulation; external aerodynamics; fluid dynamics; mathematical modeling; numerical methods; unsteady flow; *21044*.
- vortex viscosity; fast transport coefficients; Kubo-Green relation; nonequilibrium dynamics; *21238*.
- vorticity; buoyant convection; finite difference computations; fire-enclosure; fluid flow; Lanczos smoothing; partial differential equations; stream function; *J. Res. 87(2)*: 165-185; 1982 March-April.
- V,V&T technique and tools; environment; software development and maintenance; software validation; standards; verification and testing; *NBSIR 82-2482*.
- V,V&T techniques; V,V&T tools; automated software tools; dynamic analysis; formal analysis; software testing; software verification; static analysis; test coverage; validation; *SP500-93*.
- V,V&T tools; automated software tools; dynamic analysis; formal analysis; software testing; software verification; static analysis; test coverage; validation; V,V&T techniques; *SP500-93*.
- V XVIII; Ca XV; Cl XII; energy levels; K XIV; Sc XVI; Ti XVII; wavelengths; *21393*.
- W**
- wafer map; computer program; correlation coefficient; outlier; process validation wafer; statistical analysis; two-dimensional arrays; *NBSIR 82-2492*.
- wafer map; integrated circuits; microelectronics; process control; process validation wafer; test pattern; test structure; *20838*.
- waiting time; capacity; dam; lock; queue; simulation; *NBSIR 81-2411*.
- walkway; building; collapse; connection; construction; failure; steel; *BSS143*.
- wall-coated open-tubular columns; gas-liquid chromatography; liquid crystals; polycyclic aromatic hydrocarbons; *20963*.
- wall coverings; building materials; fire tests; flame attachment; heat flux; ignition; room fires; *NBSIR 82-2503*.
- wall friction; building pipe drains; low water usage devices; pitch of the pipe; plumbing drainage system; plumbing fixtures; transport mechanisms; transport phenomena; *SP624*; 1982 June. 293-326.
- wall protection; walls; wood; chimneys; fire tests; flues; heating equipment; literature reviews; radiant energy; stoves; *NBSIR 82-2506*.
- walls; aircraft compartments; aircraft fires; ceilings; compartment fires; computer programs; fire growth; fire models; heat flux; mathematical models; *NBS-GCR-82-404*.
- walls; wood; chimneys; fire tests; flues; heating equipment; literature reviews; radiant energy; stoves; wall protection; *NBSIR 82-2506*.
- warded lock; ace type pin tumbler lock; cheek plate tamper resistance; salt spray corrosion resistance; *21199*.
- warning; communication; design issues; hazard; pictograms; pictorial; safety; signs; standards; symbols; visual alerting; *BSS141*.
- waste flow; water conservation; watersaving devices; controlled installation; leak detection; preventive maintenance; rental apartment complexes; *SP624*; 1982 June. 169-171.
- waste heat recovery; absorption chillers; boiler performance; diesel engine performance; engine-generator efficiency; integrated utility system; total energy systems-economic and engineering analysis; *NBSIR 82-2483*.
- waste oil; lubricants; oil recycling; petroleum; pollution control; reclaiming; re-refining; used oil; *21383*.
- waste removal; water closets; residential water use; sanitary performance; surface cleansing; test methods; volumetric efficiency; *SP624*; 1982 June. 273-280.
- wastewater flow reduction; water conservation; *SP624*; 1982 June. 123-133.
- wastewater flow reduction; water conservation; faucet aerators; flow reduction; groundwater law; public awareness; toilet dams; *SP624*; 1982 June. 151-154.
- wastewater flows; water conservation; plumbing codes; plumbing fixtures; *SP624*; 1982 June. 379-397.
- wastewater treatment; flow reduction; *SP624*; 1982 June. 81-90.
- wastewater treatment; wastewater treatment utilities; water supply utilities; household water conservation program; potable water conservation; *SP624*; 1982 June. 247-258.
- wastewater treatment; water conservation; water-saving devices; major costs; *SP624*; 1982 June. 227-238.
- wastewater treatment systems; water conservation; Potomac River and Trails Council; Project Water Watch; *SP624*; 1982 June. 69-80.
- wastewater treatment utilities; water supply utilities; household water conservation program; potable water conservation; wastewater treatment; *SP624*; 1982 June. 247-258.
- water; absorbed dose; calorimeter; convection; heat defect; radiation chemistry; thermistor; *J. Res. 87(3)*: 211-235; 1982 May-June.
- water; absorption; adhesion; adsorption; conceptual models; corrosion; mathematical models; organic coating; osmosis; osmotic pressure; oxygen; permeability; pigment; protective performance; substrate; vehicle; *TN1150*.
- water; algorithms; calibration; chemical reactions; gas flow; gas transfer; mass spectrometer; moisture measurement; oxygen; software; sorption; *SP400-72*; 1982 April. 3-7.
- water; corrosion; friction reduction; pipes; potable water; pressure reduction; residential buildings; sprinkler systems; *NBS-GCR-82-399*.
- water; equation; flow; horizontal; motion; partially-filled pipe; slope; solid; stream-depth; surge; transport; velocity; *NBSIR 81-2450*.
- water; hydrogen; oxygen; photon stimulated desorption; PSD; synchrotron radiation; titanium; ultraviolet photoemission spectroscopy; UPS; *21005*.
- water; x rays; coherent scattering; cross section; form factor; Rayleigh scattering; tabulation; *JPCRD 11(4)*: 1091-1098; 1982.
- water calibration; accountability tank; calibration; differential pressure; volume; volumetric test measures; *TN1158*.
- water calorimeter; absorbed dose; adiabatic; calorimeter; polyethylene film; thermistor; *U.S. Patent 4,312,224*.
- water closets; residential water use; sanitary performance; surface cleansing; test methods; volumetric efficiency; waste removal; *SP624*; 1982 June. 273-280.
- water conservation; agricultural water uses; demand reduction; drought emergency plans; educational programs; rural areas; *SP624*; 1982 June. 465-469.
- water conservation; American Water Works Association (AWWA); conservation policy; *SP624*; 1982 June. 207-209.
- water conservation; conservation laws; Environmental Policy Institute; *SP624*; 1982 June. 61-66.
- water conservation; consumer education; drought-tolerant plant; *SP624*; 1982 June. 27-36.
- water conservation; consumer education; energy conservation; feedback; incentives; metering; rate structures; *NBSIR 80-2119*.
- water conservation; depletion of supply; myth of abundant water; quality degradation; *SP624*; 1982 June. 155-156.
- water conservation; faucet aerators; flow reduction; groundwater law; public awareness; toilet dams; wastewater flow reduction; *SP624*; 1982 June. 151-154.
- water conservation; flow reductions; *SP624*; 1982 June. 471-477.
- water conservation; land use planning; residential development; *SP624*; 1982 June. 103-111.
- water conservation; municipal water systems; potable water reduction; *SP624*.
- water conservation; plumbing codes; plumbing fixtures; wastewater flows; *SP624*; 1982 June. 379-397.



water conservation; Potomac River and Trails Council; Project Water Watch; wastewater treatment systems; *SP624*; 1982 June. 69-80.

water conservation; public education programs; urban water resource planning; *SP624*; 1982 June. 179-190.

water conservation; wastewater flow reduction; *SP624*; 1982 June. 123-133.

water conservation; water-conserving devices; faucet aerators; irrigation conservation; landscaping alternatives; *SP624*; 1982 June. 53-59.

water conservation; water distribution systems; water supply simulation model; analytical mathematical modeling; data base management; spatial economics; *SP624*; 1982 June. 239-245.

water conservation; water fixtures; water heating facilities; flow reduction; plumbing; *SP624*; 1982 June. 281-288.

water conservation; water planning; Federal Water Resource Agency; *SP624*; 1982 June. 373-378.

water conservation; water pricing; water rate schedules; average price; economic analysis; marginal price; *21142*.

water conservation; water-related expenditures; benefits; costs; *SP624*; 1982 June. 259-266.

water conservation; water resource management; U.S. Water Resources Council; *SP624*; 1982 June. 91-102.

water conservation; water resources planning; water system leak detection; in-school education; residential water conservation devices; *SP624*; 1982 June. 401-407.

water conservation; watersaving devices; controlled installation; leak detection; preventive maintenance; rental apartment complexes; waste flow; *SP624*; 1982 June. 169-171.

water conservation; water-saving devices; major costs; wastewater treatment; *SP624*; 1982 June. 227-238.

water conservation; water use habit changes; source of supply; *SP624*; 1982 June. 147-150.

water conservation device; low-water-using bathroom fixtures; residential water savings; retrofitting; *SP624*; 1982 June. 329-337.

water conservation education program; conservation program; *SP624*; 1982 June. 443-447.

water conservation plan; water supply planners; *SP624*; 1982 June. 211-223.

water conservation planning; water resource development; water resources; groundwater resources; *SP624*; 1982 June. 197-206.

water conservation practices; demand management; supply management; Thames Water Authority; United Kingdom; *SP624*; 1982 June. 367-372.

water conservation program; water rights; *SP624*; 1982 June. 113-119.

water-conserving devices; faucet aerators; irrigation conservation; landscaping alternatives; water conservation; *SP624*; 1982 June. 53-59.

water consumption; water-saving plumbing; control water flow; flow control devices; multi-housing properties; plumbing fixtures; *SP624*; 1982 June. 47-51.

water determination; automatic titration; Karl Fischer reagent titration; moisture; nuclear safeguards; plutonium dioxide; *NBSIR 82-2496*.

water determination; water extraction; Karl Fischer titration; methanol-water mixtures; solvent contraction; solvent-water mixtures; *21277*.

water distribution systems; water supply simulation model; analytical mathematical modeling; data base management; spatial economics; water conservation; *SP624*; 1982 June. 239-245.

water education; water education materials; water resource issues; *SP624*; 1982 June. 173-177.

water education materials; water resource issues; water education; *SP624*; 1982 June. 173-177.

water extraction; Karl Fischer titration; methanol-water mixtures; solvent contraction; solvent-water mixtures; water determination; *21277*.

water fixtures; water heating facilities; flow reduction; plumbing; water conservation; *SP624*; 1982 June. 281-288.

water heater; energy conservation; energy consumption; flow control valve; heat pump; stratification; test method; *NBSIR 81-2372*.

water heating facilities; flow reduction; plumbing; water conservation; water fixtures; *SP624*; 1982 June. 281-288.

water law; conservation; riparian doctrine; *SP624*; 1982 June. 17-26.

waterline voltage monitor; capacity divider; high voltage divider; pulse voltage monitor; voltage monitor; *SP628*; 1982 June. 20-25.

water phantom; cobalt-60 gamma rays; Compton scatter; fluence scaling; graphite phantom; ionization chamber; *21055*.

water planning; Federal Water Resource Agency; water conservation; *SP624*; 1982 June. 373-378.

water pricing; water rate schedules; average price; economic analysis; marginal price; water conservation; *21142*.

water rate schedules; average price; economic analysis; marginal price; water conservation; water pricing; *21142*.

water-related expenditures; benefits; costs; water conservation; *SP624*; 1982 June. 259-266.

water resource development; water resources; groundwater resources; water conservation planning; *SP624*; 1982 June. 197-206.

water resource issues; water education; water education materials; *SP624*; 1982 June. 173-177.

water resource management; U.S. Water Resources Council; water conservation; *SP624*; 1982 June. 91-102.

water resources; groundwater resources; water conservation planning; water resource development; *SP624*; 1982 June. 197-206.

water resources planning; water system leak detection; in-school education; residential water conservation devices; water conservation; *SP624*; 1982 June. 401-407.

water-rich hydrates; crystal structure; hydration of  $\text{XO}_4$  ion; magnesium arsenate hydrate; magnesium phosphate hydrate; struvite analogue; *20873*.

water rights; water conservation program; *SP624*; 1982 June. 113-119.

water samples; chrysotile asbestos; fiber; glass; mass concentrations; *SP619*; 1982 March. 121-131.

watersaving devices; controlled installation; leak detection; preventive maintenance; rental apartment complexes; waste flow; water conservation; *SP624*; 1982 June. 169-171.

water-saving devices; major costs; wastewater treatment; water conservation; *SP624*; 1982 June. 227-238.

water-saving plumbing; control water flow; flow control devices; multi-housing properties; plumbing fixtures; water consumption; *SP624*; 1982 June. 47-51.

water-saving plumbing devices; appliances; conservation programs; residential water conservation; *SP624*; 1982 June. 193-196.

water sorption; absorption; composite resins; expansion; hardening shrinkage; hygroscopic expansion; polymerization; *21052*.

water sorption phenomenon; Cerdips; desorption; mass spectrometry; moisture evolution analysis; *SP400-72*; 1982 April. 213-219.

water source heat pumps; central heating equipment; cooling; heating; heating seasonal performance; heating seasonal performance factor; heat pumps; test method; *NBSIR 81-2287*.

water supply planners; water conservation plan; *SP624*; 1982 June. 211-223.

water supply simulation model; analytical mathematical modeling; data base management; spatial economics; water conservation; water distribution systems; *SP624*; 1982 June. 239-245.

water supply utilities; household water conservation program; potable water conservation; wastewater treatment; wastewater treatment utilities; *SP624*; 1982 June. 247-258.

water system leak detection; in-school education; residential water conservation devices; water conservation; water resources planning; *SP624*; 1982 June. 401-407.

water tunnel; waves; drag; oscillatory flow; phase dependent; ripple; sand; sea bed; stress; time dependent; unsteady; *21332*.

water use habit changes; source of supply; water conservation; *SP624*; 1982 June. 147-150.

water use patterns; peak management; *SP624*; 1982 June. 453-464.

water vapor; calibration; certification; mass spectrometry; method 1018.2; quantitative analysis; *SP400-72*; 1982 April. 39-48.

water vapor; certification; mass spectrometry; Method 1018; quantitative analysis; standards; *SP400-72*; 1982 April. 32-38.

water vapor; contamination; dew point; hermetic packages; moisture; packaging; *SP400-72*; 1982 April. 76-78.

water vapor; corona discharges; electron avalanches; gas chromatograph; mass spectrometer;  $\text{SF}_6$ ; streamer pulses; sulfurhexafluoride; *21379*.

water vapor; derivative spectroscopy; diode laser; humidity; infrared; microcircuits; moisture; reliability; *SP400-72*; 1982 April. 105-109.

water vapor; dew point; hermetic packages; mass spectrometer; seam sealing; sensor chips; standards; *SP400-72*; 1982 April. 49-63.

water-vapor measurement; mass spectrometer; mass spectrometer calibration; mass spectrometer calibration factor; mass spectrometer sensitivity factor; moisture analysis; moisture measurement; three volume calibration valve; three volume calibrator; *SP400-72*; 1982 April. 8-14.

watt-hour meter; counter; timer; *21266*.

wave equations; dyadic Green functions; electromagnetic scattering; integral equations; perfect conductors; transient electromagnetic



fields; *TN1157*.

waveform; discrete Fourier transform; Fourier analysis; *21404*.

waveform analysis; waveform recording; automated oscilloscope; computer aided measurement; laboratory automation; pulse analysis; pulse waveform analysis; *SP634*; 1982 June. 55-67.

waveform calibration; waveform recording system; waveforms; calibration; digitizers; *SP634*; 1982 June. 35-46.

waveform digitizers; data reduction; sinewave; *SP634*; 1982 June. 23-25.

waveform generation; waveform measurements; calibration; reference waveform generators; rise time; time domain measurements; transfer standards; transition duration; *SP634*; 1982 June. 69-88.

waveform generation; waveform measurements; waveform recorder; converters; electromagnetics; encoders; pulse; standards; *SP634*.

waveform measurements; calibration; reference waveform generators; rise time; time domain measurements; transfer standards; transition duration; waveform generation; *SP634*; 1982 June. 69-88.

waveform measurements; waveform recorder; converters; electromagnetics; encoders; pulse; standards; waveform generation; *SP634*.

waveform measurements; waveform recorders; errors; pulse measurements; time domain measurements; *SP634*; 1982 June. 1-5.

waveform recorder; analog-to-digital converter; digital processing; dynamic testing; sine-wave testing; transient digitizer; transient response; *SP634*; 1982 June. 27-34.

waveform recorder; converters; electromagnetics; encoders; pulse; standards; waveform generation; waveform measurements; *SP634*.

waveform recorders; errors; pulse measurements; time domain measurements; waveform measurements; *SP634*; 1982 June. 1-5.

waveform recording; automated oscilloscope; computer aided measurement; laboratory automation; pulse analysis; pulse waveform analysis; waveform analysis; *SP634*; 1982 June. 55-67.

waveform recording system; waveforms; calibration; digitizers; waveform calibration; *SP634*; 1982 June. 35-46.

waveforms; calibration; digitizers; waveform calibration; waveform recording system; *SP634*; 1982 June. 35-46.

waveform synthesis; ac-dc difference; data conversion; dynamic response; linearity; metrology support; phase angle calibration; signal sampling; stability; *21027*.

wave immittance; electromagnetic waves; graded materials; inhomogeneous media; jellium; optical reflections; reflection coefficient; Ricatti equation; surface reflections; *TN1171*.

wavelength; Ce; energy levels; Eu; Gd; Ho; Nd; Pr; Sm; Tb; *20877*.

wavelength of light in air; air density; index of refraction of air; refractivity of air; *21276*.

wavelengths; actinide; energy; energy levels; ionization parametric interpretation; thorium; *20878*.

wavelengths; V XVIII; Ca XV; Cl XII; energy levels; K XIV; Sc XVI; Ti XVII; *21393*.

wavelengths; Xe VIII; Ba X; Cs IX; I VII; La XI; *20815*.

wavelength-size scalar horns; antenna directivity pattern; antenna measurements; calculated radiation parameters; polarization; standard antennas; VHF-UHF frequency range; *21222*.

wave mechanical lineshapes; argon; binary mixtures; collision-induced absorption; potential functions; spectral moments; translational spectrum; *20929*.

wavemeter; Fizeau; interferometer; laser wavelength meter; *20862*.

wave propagation; composites; elastic constants; elastic-wave scattering; fiber-reinforced composites; particulate composites; *20884*.

waves; drag; oscillatory flow; phase dependent; ripple; sand; sea bed; stress; time dependent; unsteady; water tunnel; *21332*.

wear; aluminum non-skid coating; corrosion control; erosion; flame spray process; plasma coatings; thermal deposition systems; thermospray process; *SP640*; 1982 October. 194-196.

wear; amalgam; apparatus; composite; dental; instrumentation; pin and disc; restorative; *20916*.

wear; corrosion; failure prevention; human performance; material and material processing; mechanical and structural failure; operational environment; preventive maintenance; *SP640*; 1982 October. 2-16.

wear; wear debris; antimony thioantimonate; electron microscopy; lubricant additive; solid lubricant; *NBSIR 82-2545*.

wear; wear debris analysis; diagnostics; ferrography; health monitoring; tribology; *SP640*; 1982 October. 466-475.

wear; wear testing; chromium; coatings; electrodeposition; metallic glasses; nickel-phosphorus; steel; *21232*.

wear debris; antimony thioantimonate; electron microscopy; lubricant additive; solid lubricant; wear; *NBSIR 82-2545*.

wear debris analysis; diagnostics; ferrography; health monitoring; tribology; wear; *SP640*; 1982 October. 466-475.

wear-metal analysis; colorimetric iron kit; iron; jet engine oil; portable; rapid; *SP640*; 1982 October. 455-465.

wear testing; chromium; coatings; electrodeposition; metallic glasses; nickel-phosphorus; steel; wear; *21232*.

weathering of cover plates; artificial weathering; cover plate materials; durability; natural weathering; solar collectors; solar energy; solar energy transmittance; tensile properties; *TN1170*.

weatherization; Community Action Agencies; Community Services Administration; costs of residential weatherization; energy conservation; field measurement of building energy consumption; optimal weatherization; residential energy consumption; *BSS144*.

weatherization; Community Services Administration Weatherization Demonstration; costs of weatherization; energy conservation; energy consumption data; energy related data; field measurement of building energy use; Optimal Weatherization Demonstration; residential energy consumption; space heating consumption; *TN1156*.

Weibull; windspeeds; Extreme Type II; hurricanes; *21211*.

weighing; constant loading; high precision; load cell; mass comparator; substitution weighing; *J. Res. 87(1)*: 47-48; 1982 January-February.

Weighmaster Law; basic weights and measures law; method of sale of commodities; open dating; packaging and labeling; registration of servicepersons; unit pricing; *H130*, 1983 Edition.

weight average molecular weight; copolymerization; fractionation; kinetics; methyl methacrylate; molecular weight dispersion; number average molecular weight; organotin polymer; size exclusion chromatography (SEC); tin-specific graphite furnace atomic absorption (GFAA); tributyltin methacrylate; ultraviolet absorbance; *20955*.

weighted average; weighted least squares regression; ANOVA (within-between); components of variance; consensus values; design of experiments; pooling of variance; *J. Res. 87(5)*: 377-385; 1982 September-October.

weighted least squares regression; ANOVA (within-between); components of variance; consensus values; design of experiments; pooling of variance; weighted average; *J. Res. 87(5)*: 377-385; 1982 September-October.

weighted ordinate; air mass; ASTM E 424; integrating sphere spectrophotometer; reflectance; selected ordinate; solar absorber materials; solar cover plates; transmittance; *NBSIR 81-2448*.

weight gain; concentration coefficient of diffusivity; density; diffusion coefficient; drawing stress; low density polyethylene; plastic deformation; sorbate concentration; sorption; *20876*.

weights; length-measuring devices; liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; user requirements; volume-measuring devices; *H44*.

weights and measures; education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; *SP629*.

welded steel bridges; fracture control; nondestructive inspection; quality control; *SP621*; 1982 October. 130-142.

weld evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; *21242*.

weld flaw inspection; flaw analysis from radiographs; flaw depth determinations; pipeline radiographic inspection; radiographic nondestructive testing; *SP621*; 1982 October. 165-173.

welding; brittle fracture; failure; fatigue; rapid transit; steel frames; *SP621*; 1982 October. 110-129.

welding consumables; weld metal impact requirement; arctic pipelines; arc welding fluxes and wires; *SP621*; 1982 October. 174.

welding evaluation; mechanical properties; nondestructive evaluation; nondestructive testing; ultrasonic testing; ultrasonic transducers; ultrasonic waves; *21235*.

weld metal impact requirement; arctic pipelines; arc welding fluxes and wires; welding consumables; *SP621*; 1982 October. 174.

weld porosity; nondestructive evaluation; titanium plate; titanium welds; ultrasonic C-scan; ultrasonic velocity; *NBSIR 82-2500*.

white noise; flicker noise; frequency-domain stability; frequency stability; oscillator noise modeling; power law spectrum; time-domain stability; *21209*.

white noise; flicker noise; frequency stability; oscillator noise modeling; power law spectra; time-domain stability; *21284*.



wide-band transformer; current transformer; *SP628*; 1982 June. 233-243.

WIN; analytical; capacity planning; central server; disk; main memory contention; modeling; packet switch; performance evaluation; simulation; trunk; *SP500-95*; 1982 October. 97-106.

wind; climatology; extreme winds; fluid mechanics; meteorology; structural engineering; *21212*.

wind effects; aircraft compartments; aircraft fires; flow rates; mathematical models; *NBSIR 82-2537*.

wind energy; biomass; heating and cooling; performance criteria; photovoltaics; solar energy systems; standards; *21106*.

wind forces; anchors; cyclic loading; field testing; flood forces; foundations; load capacity; mobile homes; soil anchors; soil mechanics; stiffness; *BSS142*.

window; window management; control; daylight; energy balance; natural ventilation; psychological needs; view out; *21043*.

window management; control; daylight; energy balance; natural ventilation; psychological needs; view out; window; *21043*.

windspeeds; Extreme Type II; hurricanes; Weibull; *21211*.

WKB approximation; adiabatic electronic-rotational states; atomic scattering; distorted wave approximation; fine structure transitions; Hund's coupling; *20786*.

wood; absorption; CO<sub>2</sub> laser; decomposition; ignition; polymethacrylate; radiation; surface temperature; *20792*.

wood; chimneys; creosote; fire safety; fire tests; flues; heating equipment; stoves; *NBS-GCR-82-368*.

wood; chimneys; creosote; fire safety; flues; heating equipment; stoves; tar; temperature measurements; *NBS-GCR-81-365*.

wood; chimneys; fire tests; flues; heating equipment; literature reviews; radiant energy; stoves; wall protection; walls; *NBSIR 82-2506*.

wood; durability; duration of load; life data; life distribution; reliability; service life; *20809*.

wood; fire endurance; fire tests; flame through; floors; furnace tests; joists; steel; *NBSIR 82-2488*.

wood crib fires; compartment fires; fire endurance; fire engineering design; liquid pool fires; thermoplastic pool fires; *21093*.

word processing; microprocessors; personal computers; small computers; software; *NBSIR 82-2573*.

worker productivity; breakdown maintenance; labor problems; maintenance; management support; manpower utilization; *SP640*; 1982 October. 495-504.

workload characterization; benchmarking; capacity planning; chargeback systems; computer performance management systems; queuing models; resource measurement facilities; simulation; supercomputers; *SP500-95*.

workload characterization; capacity planning; job accounting; resource management; statistical analysis; *SP500-95*; 1982 October. 259-273.

workload characterization; workload measurement; computer accounting; representative workload; system monitoring; *SP500-95*; 1982 October. 111-120.

workload forecasting; basic agreement solicitations; evaluation of system life costs; teleprocessing services procurements; unbalanced pricing; *SP500-95*; 1982 October. 27-33.

workload forecasting; life-cycle management; quantitative forecasting techniques; *SP500-95*; 1982 October. 435.

workload measurement; computer accounting; representative workload; system monitoring; workload characterization; *SP500-95*; 1982 October. 111-120.

workload scheduling; batch; DSNAM ENQUEUE conflict management; MVS SRM; resource-sensitive job scheduling; service levels; SMF exits; *SP500-95*; 1982 October. 297-311.

W(100); W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; *20825*.

W(110); W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); *20825*.

W(111); CH<sub>4</sub>; decomposition; heterogeneous catalysis; hydrogen; methanation; NH<sub>3</sub>; Ni(100); Ni(111); oxygen; Rh(111); structural effects; structure-insensitive; structure-sensitive; W(100); W(110); *20825*.

## X

xanthomegnin; absolute configuration; crystal structure; dimer; fungal pigment; metabolite of pathogenic fungi; single crystal x-ray diffraction; *21313*.

Xe; clusters; coincidence; mass spectrometry; photoelectron spectroscopy; photoionization; *21153*.

Xe VIII; Ba X; Cs IX; I VII; La XI; wavelengths; *20815*.

x ray; calibration; instruments; measurements; standards; traceability; *SP609*; 1982 February. 59-64.

x ray; crystal data; diffraction; Hanawalt search procedure; powder diffraction file; *21271*.

x ray; digitizing anode; gamma ray; microchannel plate; multiple-pinhole mask; spectrometer; telescope; *21366*.

x ray; image formation; kinetic study; materials science; synchrotron radiation; topography; *21257*.

x-ray diffraction; active site; charge relay; enzymes; protein structure; ribonuclease; *20893*.

x-ray diffraction; analgesic; anticonvulsant; azepine ring; carbamazepine; crystal structure; molecular structure; USP reference standard; *21298*.

x-ray diffraction; Barkhausen noise; energy dispersive diffractometry; high-energy x rays; hole-drilling method; neutron diffraction; nondestructive evaluation; residual stress; stress measurements; ultrasonics; *20926*.

x-ray diffraction; copolymers; crystal; hexafluoropropylene; polytetrafluoroethylene; tetrafluoroethylene; *21164*.

x-ray diffraction; crystal structure; densities; lattice constants; powder patterns; reference intensities; standard; *Monogr. 25, Section 19*.

x-ray diffraction; crystal structure; inner salt; iodonium compound; ionic bonding; reaction intermediate; *21268*.

x-ray diffraction; diffraction; high-energy x-rays; internal stress; neutron diffraction; nondestructive evaluation; residual stress; stress analysis; *21359*.

x-ray diffraction; fatigue; hole drilling; nondestructive evaluation; photoelasticity; research needs; residual stress; standards; stress measurement; terminology; ultrasonics; *21344*.

x-ray edge; dispersion relation; perturbation theory; singularity; *20960*.

x-ray edge; inelastic scattering; sticking; surface processes; *21152*.

x-ray emission; electron production; multiple ionization; vacancies; *21261*.

x-ray emission lines; x-ray photoelectron spectra; crystal spectroscopy; electrons; excitation; measurement; *21330*.

x-ray extinction; x-ray imaging; x-ray topography; dynamical diffraction theory; *21258*.

x-ray fluorescence; austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; *SP260-78*.

x-ray fluorescence; austenite in ferrite; powder metallurgy; quantitative microscopy; retained austenite standard; standard reference material; *SP260-76*.

x-ray image magnification; multicrystal diffraction; real time; synchrotron; topography; *21259*.

x-ray imaging; x-ray topography; dynamical diffraction theory; x-ray extinction; *21258*.

x-ray interferometry; x rays; crystal diffraction; gamma-ray standards; precision measurement; *21086*.

x-ray magnifier; acoustic emission simulator; acoustic emission transducers; nondestructive evaluation; penetrant test block; traceable measurements; ultrasonic reference blocks; ultrasonic transducers; *21181*.

x-ray methods; active site; hydrogen bonds; protein structure; ribonuclease-S; semi-synthetic proteins; *20914*.

x-ray photoelectron spectra; crystal spectroscopy; electrons; excitation; measurement; x-ray emission lines; *21330*.

x-ray photoelectron spectroscopy; Auger-electron spectroscopy; ESCA (electron spectroscopy for surface analysis); ion-scattering spectroscopy; secondary-ion mass spectroscopy; surface analysis; *21382*.

x rays; atomic spectra; atomic wavelengths; He-like ions; isoelectronic sequence; spectra series; vacuum ultraviolet; *20803*.

x rays; coherent scattering; cross section; form factor; Rayleigh scattering; tabulation; water; *JPCRD 11(4)*: 1091-1098; 1982.



x rays; crystal diffraction; gamma-ray standards; precision measurement; x-ray interferometry; 21086.  
 x rays; diffractometry; macromolecular crystallography; neutrons; position-sensitive detectors; precision of data; 20982.  
 x rays; joint refinement; macromolecular structures; neutron; restrained refinement; single crystals; 21136.  
 x rays, binaries; pulsars; stars, individual; 21009.  
 x rays, binaries; radiation mechanisms; stars, accretion; stars, magnetic; stars, neutron; 21171.  
 x-ray spectrometry; cation exchange resin-loaded filters; environmental samples; ultratrace analysis; 21364.  
 x-ray spectroscopy; Auger spectroscopy; depth profiling; sputtering; surface analysis; thin films; 20985.  
 x-ray topography; copper single crystal; image contrast; indentation hardening; plastic deformation; 21353.  
 x-ray topography; dynamical diffraction theory; x-ray extinction; x-ray imaging; 21258.

## Y

yield; integrated circuits; microelectronics; process control; process validation wafer; silicon on sapphire; test chip; test pattern; test structure; NBSIR 82-2514.  
 yield strength; Young's modulus; compressive strength; concrete mortar; elongation; low temperature; maximum strength; mechanical properties; NBSIR 82-1658.  
 Young's modulus; boron-aluminum; elastic constants; glass-epoxy; graphite-epoxy; internal friction; shear modulus; sound velocity; ultrasonic wave; 20868.  
 Young's modulus; bulk modulus; elastic constants; low-temperature; magnetic transition; physical properties; Poisson's ratio; shear modulus; sound velocity; stainless steel; 21198.  
 Young's modulus; compressive strength; concrete mortar; elongation; low temperature; maximum strength; mechanical properties; yield strength; NBSIR 82-1658.  
 ytterbium; Auger; core-holes; mixed-valence; photoionization; resonance; 21105.  
 ytterbium; barium; dysprosium; energy levels; erbium; gadolinium; neodymium; samarium; spectrum; tantalum; tungsten; 20845.  
 yttrium; atomic ordering; iron; magnetism; manganese; 20866.  
 yttrium; energy level; ionization energy; spark; spectrum; ultraviolet; 21240.  
 yttrium; ion; laser-produced plasma; spectrum; strontium; vacuum ultraviolet; 21356.  
 yttrium; zirconium; molybdenum; niobium; spectra; strontium; vacuum ultraviolet; 21179.  
 Yukawa potential; bandgap narrowing; band states; donor impurities; Germi energy; silicon; 20921.  
 Yukawa potential; bandgap narrowing; Bargmann potential; conduction states; donors; effective mass; energy dispersion; impurities; silicon; valence states; 20855.

## Z

Zeeman effect; CH; far infrared; hyperfine constants; lambda doubling; laser magnetic resonance; rotational levels; 21273.  
 Zero Gradient Synchrotron; current transformers; precision shunts; pulsed currents; SP628; 1982 June. 204-216.  
 zinc; dietary enrichment; isotopes; mass spectrometry; neutron activation; plasma; 21374.  
 zinc oxide; chemisorption; hydrogen; hydrogen deuterate; kinetic isotope effect; transition state; 20971.  
 zinc point; aluminum point; cadmium point; check thermometers; freezing point; melting point; mercury point; phase equilibrium; standard platinum resistance thermometer (SPRT); thermometric fixed point; tin point; triple point; SP260-77.  
 zirconium; molybdenum; niobium; spectra; strontium; vacuum ultraviolet; yttrium; 21179.  
 Zn<sup>+</sup>; crossed beams; cross sections; electron impact excitation; lifetime; polarization; 21072.  
 Zn<sup>+</sup>; crossed beams; electron impact; excitation-autoionization; Ga<sup>+</sup>; ionization; 21071.  
 1-fluorocyclohexadienyl; benzene; F-atom reactions; infrared spectrum; matrix isolation; phenyl; photodecomposition; 20917.  
 1 keV photon energy region; beryl; KAP; metallic multilayers; reflectivity; resolving power; synchrotron radiation; 21088.

100-kV rating; dc-coupled probe; 2-ns risetime; SP628; 1982 June. 46-53.  
 10.3 MeV transition; <sup>40</sup>Ca; form factor; ground state transition width; inelastic electron scattering; magnetic dipole; Rosenbluth separation; 21037.  
 1.064 μm laser pulse measurements; APD transfer standards; beamsplitter attenuator; impulse response measurements; low-level laser measurements; modulated cw measurement system; PIN transfer standards; pulse energy; pulse peak power; TN1058.  
 14 MeV neutron energy; associated particle; fission cross section; uranium-235; 20861.  
<sup>166</sup>Ho; mixing ratios; nuclear magnetic moment; nuclear orientation; nuclear quadrupole moment; γ-ray anisotropy thermometry; γ-ray transitions in <sup>166</sup>Er; 20978.  
<sup>166</sup>Ho-Ho atomic magnetism; helical spin structure; holmium single crystal; low temperature; magnetic spin structure; nuclear magnetism; nuclear orientation; γ rays; 21017.  
 2-ns risetime; 100-kV rating; dc-coupled probe; SP628; 1982 June. 46-53.  
 2s; continuum; double electron; excitation; sodium; 21331.  
 25 gram capacity flow calorimeter; enthalpy of combustion; flow calorimetry; municipal solid waste; refuse; refuse-derived-fuel; NBSIR 82-2457.  
 327X emulator; accurate data; end user; host independent; monitor; network; performance; remote; response time; series/1; sidestreaming; simulated commands; SP500-95; 1982 October. 401-407.  
<sup>40</sup>Ca; form factor; ground state transition width; inelastic electron scattering; magnetic dipole; Rosenbluth separation; 10.3 MeV transition; 21037.  
 500 kV; 500 kV substation measurements; CCVTs; EHV revenue metering; energy metering; field calibration; metering accuracy CCVTs; TN1155.  
 500 kV substation measurements; CCVTs; EHV revenue metering; energy metering; field calibration; metering accuracy CCVTs; 500 kV; TN1155.  
 π-acceptors; semiconduction; conductivity; croconates; crystallographic; electrical; electrochemical; mechanism; J. Res. 87(3): 257-260; 1982 May-June.  
 γ-ray anisotropy thermometry; γ-ray transitions in <sup>166</sup>Er; <sup>166</sup>Ho; mixing ratios; nuclear magnetic moment; nuclear orientation; nuclear quadrupole moment; 20978.  
 γ rays; <sup>166</sup>Ho-Ho atomic magnetism; helical spin structure; holmium single crystal; low temperature; magnetic spin structure; nuclear magnetism; nuclear orientation; 21017.  
 γ-ray transitions in <sup>166</sup>Er; <sup>166</sup>Ho; mixing ratios; nuclear magnetic moment; nuclear orientation; nuclear quadrupole moment; γ-ray anisotropy thermometry; 20978.



# APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

## ALABAMA

Alexander City: Alexander City State Junior College, Thomas D. Russell Library (1967).  
Auburn: Auburn University, Ralph Brown Draughon Library (1907).  
Birmingham:  
    Birmingham Public Library (1895).  
    Birmingham Southern College Library (1932).  
    Jefferson State Junior College, James B. Allen Library (1970).  
    Miles College, C. A. Kirkendoll Learning Resource Center (1980).  
    Samford University Library (1884).  
Enterprise: Enterprise State Junior College, Learning Resources Center (1967).  
Fayette: Brewer State Junior College, Learning Resources Center Library (1979).  
Florence: University of North Alabama, Collier Library (1932).  
Gadsden: Gadsden Public Library (1963).  
Huntsville: University of Alabama in Huntsville Library (1964).  
Jacksonville: Jacksonville State University Library (1929).  
Mobile:  
    Mobile Public Library (1963).  
    Spring Hill College, Thomas Byrne Memorial Library (1937).  
    University of South Alabama Library (1968).  
Montgomery:  
    Alabama State Department of Archives and History Library (1884).  
    Alabama Supreme Court and State Law Library (1884).  
    Auburn University at Montgomery Library (1971)-REGIONAL.  
Maxwell A.F. Base: Air University Library (1963).  
Normal: Alabama Agricultural and Mechanical College, J. F. Drake Memorial Learning Resources Center (1963).  
Troy: Troy State University Library (1963).  
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).  
University:  
    University of Alabama Library (1860)-REGIONAL.  
    University of Alabama, School of Law Library (1967).

## ALASKA

Anchorage:  
    Anchorage Municipal Libraries, Z. J. Loussac Public Library (1978).  
    Supreme Court of Alaska Library (1973).  
    University of Alaska at Anchorage Library (1961).  
    U.S. Department of Interior, Alaska Resources Library (1981).  
Fairbanks: University of Alaska, Elmer E. Rasmuson Library (1922).  
Juneau:  
    Alaska State Library (1900).  
    University of Alaska-Juneau Library (1981).  
Ketchikan: Ketchikan Community College Library (1970).

## ARIZONA

Coolidge: Central Arizona College, Instructional Materials Center (1973).  
Flagstaff: Northern Arizona University Library (1937).  
Phoenix:  
    Department of Library, Archives, and Public Records (unknown)-REGIONAL.  
    Grand Canyon College, Fleming Library (1978).  
    Phoenix Public Library (1917).  
Prescott: Yavapai College Library (1976).  
Tempe:  
    Arizona State University, College of Law Library (1977).  
    Arizona State University Library (1944).  
Thatcher: Eastern Arizona College Library (1963).  
Tucson:  
    Tucson Public Library (1970).  
    University of Arizona Library (1907)-REGIONAL.

Yuma: Yuma City-County Library (1963).

## ARKANSAS

Arkadelphia: Ouachita Baptist University, Riley Library (1963).  
Batesville: Arkansas College Library (1963).  
Clarksville: College of the Ozarks, Dobson Memorial Library (1925).  
Conway: Hendrix College, Olin C. Bailey Library (1903).  
Fayetteville:  
    University of Arkansas Library (1907).  
    University of Arkansas, School of Law Library (1978).  
Little Rock:  
    Arkansas State Library-REGIONAL. (1978).  
    Arkansas Supreme Court Library (1962).  
    Little Rock Public Library (1953).  
    University of Arkansas at Little Rock Library (1973).  
    University of Arkansas at Little Rock Law Library (1979).  
Magnolia: Southern Arkansas University, Magale Library (1956).  
Monticello: University of Arkansas at Monticello Library (1956).  
Pine Bluff: University of Arkansas at Pine Bluff, Watson Memorial Library (1976).  
Russellville: Arkansas Tech University, Tomlinson Library (1925).  
Searcy: Harding University, Beaumont Memorial Library (1963).  
State University: Arkansas State University, Dean B. Ellis Library (1913).  
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

## CALIFORNIA

Anaheim: Anaheim Public Library (1963).  
Arcadia: Arcadia Public Library (1975).  
Arcata: Humboldt State University Library (1963).  
Bakersfield:  
    California State College, Bakersfield Library (1974).  
    Kern County, Beale Memorial Library (1943).  
Berkeley:  
    University of California, Law Library (1963).  
    University of California, General Library (1907).  
Carson:  
    California State University, Dominguez Hills Educational Resources Center (1973).  
    Carson Regional Library (1973).  
Chico: California State University at Chico Library (1962).  
Claremont: Claremont Colleges' Libraries, Honnold Library (1913).  
Coalinga: West Hills Community College Library (1978).  
Compton: Compton Library (1972).  
Culver City: Culver City Library (1966).  
Davis:  
    University of California, Shields Library (1953).  
    University of California at Davis, Law Library (1972).  
Downey: Downey City Library (1963).  
Fresno:  
    California State University, Henry Madden Library (1962).  
    Fresno County Free Library (1920).  
Fullerton: California State University at Fullerton Library (1963).  
Garden Grove: Garden Grove Regional Library (1963).  
Gardena: Gardena Public Library (1966).  
Hayward: California State University at Hayward Library (1963).  
Huntington Park: Huntington Park Library, San Antonio Region (1970).  
Inglewood: Inglewood Public Library (1963).  
Irvine: University of California at Irvine, General Library (1963).  
La Jolla: University of California, San Diego, University Library (1963).  
Lakewood: Angelo Iacoboni Public Library (1970).  
Lancaster: Lancaster Regional Library (1967).  
La Verne: University of La Verne, College of Law Library (1979).  
Long Beach:  
    California State University at Long Beach Library (1962).  
    Long Beach Public Library (1933).



## Los Angeles:

California State University at Los Angeles, John F. Kennedy Memorial Library (1956).  
Los Angeles County Law Library (1963).  
Los Angeles Public Library (1891).  
Loyola Marymount University, Charles Von der Ahe Library (1933).  
Loyola Law School, Law Library (1979).  
Occidental College Library (1941).  
Pepperdine University Library (1963).  
Southwestern University, School of Law Library (1975).  
University of California at Los Angeles Research Library (1932).  
University of California, Los Angeles, Law Library (1958).  
University of Southern California Library (1933).  
University of Southern California, Law Library (1978).  
U.S. Court of Appeals, 9th Circuit Library (1981).  
Whittier College, School of Law Library (1978).

Menlo Park: Department of Interior, Geological Survey Library (1962).

Montebello: Montebello Library (1966).

Monterey: U.S. Naval Postgraduate School, Dudley Knox Library (1963).

Monterey Park: Bruggemeyer Memorial Library (1964).

Northridge: California State University at Northridge, Oviatt Library (1958).

Norwalk: Norwalk Public Library (1973).

## Oakland:

Mills College Library (1966).  
Oakland Public Library (1923).

Ontario: Ontario City Library (1974).

Palm Springs: Palm Springs Public Library (1980).

## Pasadena:

California Institute of Technology, Millikan Memorial Library (1933).

Pasadena Public Library (1963).

Pleasant Hill: Contra Costa County Library (1964).

Redding: Shasta County Library (1956).

Redlands: University of Redlands, Armacost Library (1933).

Redwood City: Redwood City Public Library (1966).

Reseda: West Valley Regional Branch Library (1966).

Richmond: Richmond Public Library (1943).

## Riverside:

Riverside Public Library (1947).  
University of California at Riverside Library (1963).

## Sacramento:

California State Library (1895)-REGIONAL.  
California State University at Sacramento Library (1963).  
Sacramento County Law Library (1963).  
Sacramento Public Library (1880).  
University of the Pacific, McGeorge School of Law Library (1978).

San Bernardino: San Bernardino County Free Library (1964).

## San Diego:

San Diego County Law Library (1973).  
San Diego County Library (1966).  
San Diego Public Library (1895).  
San Diego State University Library (1962).  
University of San Diego, Kratter Law Library (1967).

## San Francisco:

Golden Gate University, School of Law Library (1979).  
Hastings College of Law Library (1972).  
Mechanics' Institute Library (1889).  
San Francisco Public Library (1889).  
San Francisco State University, J. Paul Leonard Library (1955).  
Supreme Court of California Library (1979).  
U.S. Court of Appeals, Ninth Circuit Library (1971).  
University of San Francisco, Richard A. Gleeson Library (1963).

San Jose: San Jose State University Library (1962).

San Leandro: San Leandro Community Library Center (1961).

San Luis Obispo: California Polytechnic State University Library (1969).

San Rafael: Marin County Free Library (1975).

## Santa Ana:

Orange County Law Library (1975).  
Santa Ana Public Library (1959).

Santa Barbara: University of California at Santa Barbara Library (1960).

Santa Clara: University of Santa Clara, Orradre Library (1963).

Santa Cruz: University of California at Santa Cruz, McHenry Library (1963).

Santa Rosa: Sonoma County Library (1896).

## Stanford:

Stanford University Libraries (1895).

Stanford University, Robert Crown Law Library (1978).

Stockton: Public Library of Stockton and San Joaquin County (1884).

Thousand Oaks: California Lutheran College Library (1964).

Torrance: Torrance Civic Center Library (1969).

Turlock: California State College, Stanislaus Library (1964).

Vallejo: Solano County, John F. Kennedy Library (1982).

Valencia: Valencia Regional Library (1972).

Ventura: Ventura County Library (1975).

Visalia: Tulare County Free Library (1967).

Walnut: Mount San Antonio College Library (1966).

West Covina: West Covina Regional Library (1966).

Whittier: Whittier College, Wardman Library (1963).

## CANAL ZONE

Balboa Heights: Panama Canal Commission, Library Services Branch (1963).

## COLORADO

Alamosa: Adams State College, Learning Resources Center (1963).

Boulder: University of Colorado at Boulder, Government Publications Library (1879)-REGIONAL.

## Colorado Springs:

Colorado College, Tutt Library (1880).

University of Colorado at Colorado Springs, Library (1974).

## Denver:

Auraria Library (1978).

Colorado State Library (unknown).

Colorado Supreme Court Library (1978).

Denver Public Library (1884)-REGIONAL.

Department of the Interior, Water and Power Resources Service Library (1962).

Regis College, Dayton Memorial Library (1915).

University of Denver, Penrose Library (1909).

University of Denver, School of Law Library (1978).

U.S. Court of Appeals, Tenth Circuit Library (1973).

Fort Collins: Colorado State University Libraries (1907).

Golden: Colorado School of Mines, Arthur Lakes Library (1939).

Grand Junction: Mesa County Public Library (1975).

Greeley: University of Northern Colorado Library (1966).

Gunnison: Western State College, Leslie J. Savage Library (1932).

La Junta: Otero Junior College, Wheeler Library (1963).

Lakewood: Jefferson County Public Library, Lakewood Library (1968).

## Pueblo:

Pueblo Library District (1893).

University of Southern Colorado Library (1965).

U.S. Air Force Academy: Academy Library (1956).

## CONNECTICUT

### Bridgeport:

Bridgeport Public Library (1884).

University of Bridgeport School of Law Library (1979).

Danbury: Western Connecticut State College, Ruth A. Haas Library (1967).

Danielson: Quinebaug Valley Community College Library (1975).

Enfield: Enfield Central Library (1967).

### Hartford:

Connecticut State Library (unknown)-REGIONAL.

Hartford Public Library (1945).

Trinity College Library (1895).

Middletown: Wesleyan University, Olin Library (1906).

Mystic: Mystic Seaport Museum Inc., G. W. Blunt White Library (1964).

New Britain: Central Connecticut State College, Elihu Burritt Library (1973).



New Haven:  
 Southern Connecticut State College, Hilton C. Buley Library (1968).  
 Yale Law Library (1981).  
 Yale University Library (1859).  
 New London:  
 Connecticut College Library (1926).  
 U.S. Coast Guard Academy Library (1939).  
 Stamford: The Ferguson Library (1973).  
 Storrs: University of Connecticut Library (1907).  
 Waterbury:  
 Post College, Traurig Library (1977).  
 Silas Bronson Public Library (1869).  
 West Hartford: University of Connecticut, School of Law Library (1978).  
 West Haven: University of New Haven, Peterson Library (1971).

## DELAWARE

Dover:  
 Delaware State College, William C. Jason Library (1962).  
 State Law Library in Kent County (unknown).  
 Georgetown:  
 Delaware Technical and Community College Library (1968).  
 Sussex County Law Library (1976).  
 Newark: University of Delaware Library (1907).  
 Wilmington:  
 Delaware Law School Library (1976).  
 New Castle County Law Library (1974).

## DISTRICT OF COLUMBIA

Washington:  
 Administrative Conference of the United States Library (1977).  
 Advisory Commission on Intergovernmental Relations Library (1972).  
 Catholic University of America, Robert J. White Law Library (1979).  
 Civil Aeronautics Board Library (1974).  
 Department of the Army Library (1969).  
 Department of Commerce Library (1955).  
 Department of Energy Library (1963).  
 Department of Health and Human Services (1954).  
 Department of Housing and Urban Development Library (1969).  
 Department of the Interior Library (1895).  
 Department of Justice Main Library (1895).  
 Department of Labor Library (1976).  
 Department of the Navy Library (1895).  
 Department of State Library (1895).  
 Department of State Law Library (1966).  
 Department of Transportation, National Highway Traffic Safety Administration Library (1968).  
 Department of the Treasury Library (1895).  
 District of Columbia Court of Appeals Library (1981).  
 District of Columbia Public Library (1943).  
 Executive Office of the President, Office of Administration Library and Information Service Division (1965).  
 Federal Deposit Insurance Corporation Library (1972).  
 Federal Election Commission Library (1975).  
 Federal Labor Relations Authority Law Library (1982).  
 Federal Mine Safety & Health Review Commission Library (1979).  
 Federal Reserve System, Board of Governors Research Library (1978).  
 Federal Reserve System Law Library (1976).  
 General Accounting Office Library (1974).  
 General Services Administration Library (1975).  
 Georgetown University Library (1969).  
 Georgetown University Law Center, Fred O. Dennis Law Library (1978).  
 George Washington University, National Law Center (1978).  
 Library of Congress, Congressional Research Service (1978).  
 Library of Congress, Serial and Government Publications (1977).  
 Merit Systems Protection Board Library (1979).  
 National Defense University Library (1895).  
 University of the District of Columbia Library (1970).

U.S. Court of Appeals, Judges' Library (1975).  
 U.S. Office of Personnel Management Library (1963).  
 U.S. Postal Service Library (1895).  
 U.S. Senate Library (1979).  
 U.S. Supreme Court Library (1978).  
 Veterans' Administration, Central Office Library (1967).

## FLORIDA

Boca Raton: Florida Atlantic University, S. E. Wimberly Library (1963).  
 Clearwater: Clearwater Public Library (1972).  
 Coral Gables: University of Miami Library (1939).  
 Daytona Beach: Volusia County Library Center (1963).  
 De Land: Stetson University, duPont-Ball Library (1887).  
 Fort Lauderdale:  
 Broward County Library (1967).  
 Nova University Law Library (1967).  
 Fort Pierce: Indian River Community College Library (1975).  
 Gainesville:  
 University of Florida, College of Law Library (1978).  
 University of Florida Libraries (1907)-REGIONAL.  
 Jacksonville:  
 Haydon Burns Library (1914).  
 Jacksonville University, Swisher Library (1962).  
 University of North Florida, Thomas G. Carpenter Library (1972).  
 Lakeland: Lakeland Public Library (1928).  
 Leesburg: Lake-Sumter Community College Library (1963).  
 Melbourne: Florida Institute of Technology Library (1963).  
 Miami:  
 Florida International University Library (1970).  
 Miami Public Library (1952).  
 North Miami: Florida International University, North Miami Campus Library (1977).  
 Opa Locka: Biscayne College Library (1966).  
 Orlando: University of Central Florida Library (1966).  
 Palatka: St. Johns River Community College Library (1963).  
 Pensacola: University of West Florida, John C. Pace Library (1966).  
 Port Charlotte: Charlotte County Library System (1973).  
 St. Petersburg:  
 St. Petersburg Public Library (1965).  
 Stetson University College of Law, Charles A. Dana Library (1975).  
 Sarasota: Selby Public Library (1970).  
 Tallahassee:  
 Florida Agricultural and Mechanical University, Coleman Learning Resources Center (1936).  
 Florida State University, College of Law Library (1978).  
 Florida State University, Robert M. Strozier Library (1941).  
 Florida Supreme Court Library (1974).  
 State Library of Florida (1929).  
 Tampa:  
 Tampa-Hillsborough County Public Library (1965).  
 University of South Florida Library (1962).  
 University of Tampa, Merl Kelce Library (1953).  
 Winter Park: Rollins College, Mills Memorial Library (1909).

## GEORGIA

Albany: Albany-Dougherty Public Library (1964).  
 Americus: Georgia Southwestern College, James Earl Carter Library (1966).  
 Athens:  
 University of Georgia Libraries (1907)-REGIONAL.  
 University of Georgia, School of Law Library (1979).  
 Atlanta:  
 Atlanta Public Library (1880).  
 Atlanta University Center, Robert W. Woodruff Library (1962).  
 Emory University, Woodruff Library (1928).  
 Emory University, School of Law Library (1968).  
 Georgia Institute of Technology, Price Gilbert Memorial Library (1963).  
 Georgia State Library (unknown).  
 Georgia State University, William Russell Pullen Library (1970).



U.S. Court of Appeals, 5th Circuit Library (1980).  
 Augusta: Augusta College, Reese Library (1962).  
 Brunswick: Brunswick-Glynn County Regional Library (1965).  
 Carrollton: West Georgia College, Irene Sullivan Ingram Library (1962).  
 Columbus: Columbus College, Simon Schwob Memorial Library (1975).  
 Dahlonega: North Georgia College, Stewart Library (1939).  
 Dalton: Dalton Junior College Library (1978).  
 Decatur: DeKalb Community College, South Campus Learning Resources Center (1973).  
 Macon:  
   Mercer University, Stetson Memorial Library (1964).  
   Mercer University, Walter F. George School of Law Library (1978).  
 Marietta: Kennesaw College Memorial Library (1968).  
 Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).  
 Mount Berry: Berry College Memorial Library (1970).  
 Savannah: Chatham-Effingham-Liberty Regional Library (1857).  
 Statesboro: Georgia Southern College Library (1939).  
 Valdosta: Valdosta State College Library (1956).

## GUAM

Agana: Nieves M. Flores Memorial Library (1962).  
 Mangilao: University of Guam, Robert F. Kennedy Memorial Library (1978).

## HAWAII

Hilo: University of Hawaii at Hilo Library (1962).  
 Honolulu:  
   Hawaii Medical Library, Inc. (1968).  
   Hawaii State Library (1929).  
   Municipal Reference & Records Center (1965).  
   Supreme Court Law Library (1973).  
   University of Hawaii Library (1907)-REGIONAL.  
   University of Hawaii, School of Law Library (1978).  
 Laie: Brigham Young University, Hawaii Campus, Joseph F. Smith Library (1964).  
 Lihue: Kauai Regional Library (1967).  
 Pearl City: Leeward Community College Library (1967).  
 Wailuku: Maui Public Library (1962).

## IDAHO

Boise:  
   Boise Public Library and Information Center (1929).  
   Boise State University Library (1966).  
   Idaho State Law Library (unknown).  
   Idaho State Library (1971).  
 Caldwell: College of Idaho, Terteling Library (1930).  
 Moscow:  
   University of Idaho, College of Law Library (1978).  
   University of Idaho Library (1907)-REGIONAL.  
 Pocatello: Idaho State University Library (1908).  
 Rexburg: Ricks College, David O. McKay Library (1946).  
 Twin Falls: College of Southern Idaho Library (1970).

## ILLINOIS

Bloomington: Illinois Wesleyan University Libraries (1964).  
 Carbondale:  
   Southern Illinois University, Morris Library (1932).  
   Southern Illinois University, School of Law Library (1978).  
 Carlinville: Blackburn College, Lumpkin Library (1954).  
 Carterville: Shawnee Library System (1971).  
 Champaign: University of Illinois, Law Library (1965).  
 Charleston: Eastern Illinois University, Booth Library (1962).  
 Chicago:  
   Chicago Public Library (1876).  
   Chicago State University, Paul and Emily Douglas Library (1954).  
   DePaul University, Law Library (1979).

Field Museum of Natural History Library (1963).  
 Illinois Institute of Technology, Chicago-Kent College of Law Library (1978).  
 Illinois Institute of Technology, Kemper Library (1982).  
 John Crerar Library (1909).  
 John Marshall Law School Library (1981).  
 Loyola University of Chicago, E. M. Cudahy Memorial Library (1966).  
 Loyola University, School of Law Library (1979).  
 Northeastern Illinois University Library (1961).  
 Northwestern University, School of Law Library (1978).  
 University of Chicago, Law Library (1964).  
 University of Chicago Library (1897).  
 University of Illinois at Chicago Circle Library (1957).  
 William J. Campbell Library of the U.S. Courts (1979).  
 Decatur: Decatur Public Library (1954).  
 De Kalb: Northern Illinois University, Founders' Memorial Library (1960).  
 Des Plaines: Oakton Community College, Learning Resource Center (1960).  
 Edwardsville: Southern Illinois University, Lovejoy Memorial Library (1959).  
 Elsah: Principia College, Marshall Brooks Library (1957).  
 Evanston: Northwestern University Library (1876).  
 Freeport: Freeport Public Library (1905).  
 Galesburg: Galesburg Public Library (1896).  
 Glen Ellyn: Northern Illinois University, College of Law Library (1978).  
 Jacksonville: MacMurray College, Henry Pfeiffer Library (1957).  
 Kankakee: Olivet Nazarene College, Benner Library and Learning Resource Center (1946).  
 Lake Forest: Lake Forest College, Donnelley Library (1962).  
 Lebanon: McKendree College, Holman Library (1968).  
 Lisle: Illinois Benedictine College, Theodore F. Lownik Library (1911).  
 Macomb: Western Illinois University Libraries (1962).  
 Moline: Black Hawk College, Learning Resources Center (1970).  
 Monmouth: Monmouth College, Hewes Library (1860).  
 Mt. Carmel: Wabash Valley College, Bauer Media Center (1975).  
 Mt. Prospect: Mt. Prospect Public Library (1977).  
 Normal: Illinois State University, Milner Library (1877).  
 Oak Park: Oak Park Public Library (1963).  
 Oglesby: Illinois Valley Community College, Jacobs Memorial Library (1976).  
 Palos Hills: Moraine Valley Community College Library (1972).  
 Park Forest South: Governors' State University Library (1974).  
 Peoria:  
   Bradley University, Cullom Davis Library (1963).  
   Peoria Public Library (1883).  
 River Forest: Rosary College, Rebecca Crown Library (1966).  
 Rockford: Rockford Public Library (1895).  
 Romeoville: Lewis University Library (1952).  
 Springfield: Illinois State Library (unknown)-REGIONAL.  
 Streamwood: Poplar Creek Public Library District (1980).  
 Urbana: University of Illinois Library (1907).  
 Wheaton: Wheaton College Library (1964).  
 Woodstock: Woodstock Public Library (1963).

## INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).  
 Bloomington:  
   Indiana University Library (1881).  
   Indiana University, School of Law Library (1978).  
 Crawfordsville: Wabash College, Lilly Library (1906).  
 Evansville:  
   Evansville and Vanderburgh County Public Library (1928).  
   Indiana State University, Evansville Campus Library (1969).  
 Fort Wayne:  
   Indiana-Purdue Universities, Helmke Library (1965).  
   Allen County Public Library (1896).  
 Franklin: Franklin College Library (1976).  
 Gary:  
   Gary Public Library (1943).  
   Indiana University, Northwest Campus Library (1966).  
 Greencastle: De Pauw University, Roy O. West Library (1879).  
 Hammond: Hammond Public Library (1964).



Hanover: Hanover College, Duggan Library (1892).  
 Huntington: Huntington College, Loew Alumni Library (1964).  
 Indianapolis:  
   Butler University, Irwin Library (1965).  
   Indianapolis-Marion County Public Library (1906).  
   Indiana State Library (unknown)-REGIONAL.  
   Indiana Supreme Court, Law Library (1975).  
   Indiana University, School of Law Library (1967).  
   Indiana University-Purdue University Library (1979).  
 Kokomo: Indiana University at Kokomo, Learning Resource Center (1969).  
 Lafayette: Purdue University Libraries and Audio-Visual Center (1907).  
 Muncie:  
   Ball State University Library (1959).  
   Muncie Public Library (1906).  
 New Albany: Indiana University, Southeastern Campus Library (1965).  
 Notre Dame: University of Notre Dame, Memorial Library (1883).  
 Rensselaer: St. Joseph's College Library (1964).  
 Richmond:  
   Earlham College, Lilly Library (1964).  
   Morrison-Reeves Library (1906).  
 South Bend: Indiana University at South Bend Library (1965).  
 Terre Haute: Indiana State University, Cunningham Memorial Library (1906).  
 Valparaiso:  
   Valparaiso University, Moellering Memorial Library (1930).  
   Valparaiso University, Law Library (1978).

## IOWA

Ames: Iowa State University Library (1907).  
 Cedar Falls: University of Northern Iowa Library (1946).  
 Council Bluffs:  
   Free Public Library (1885).  
   Iowa Western Community College, Herbert Hoover Library (1972).  
 Davenport: Davenport Public Library (1973).  
 Des Moines:  
   Drake University, Cowles Library (1966).  
   Drake University, Law Library (1972).  
   Public Library of Des Moines (1888).  
   State Library of Iowa (unknown).  
 Dubuque:  
   Carnegie-Stout Public Library (unknown).  
   Loras College, Wahlert Memorial Library (1967).  
 Fayette: Upper Iowa University, Henderson-Wilder Library (1974).  
 Grinnell: Grinnell College Library (1874).  
 Iowa City:  
   University of Iowa College of Law, Law Library (1968).  
   University of Iowa Libraries (1884)-REGIONAL.  
 Lamoni: Graceland College, Frederick Madison Smith Library (1927).  
 Mason City: North Iowa Area Community College Library (1976).  
 Mount Vernon: Cornell College, Russell D. Cole Library (1896).  
 Orange City: Northwestern College, Ramaker Library (1970).  
 Sioux City: Sioux City Public Library (1894).

## KANSAS

Atchison: Benedictine College Library, North Campus (1965).  
 Baldwin City: Baker University, Collins Library (1908).  
 Colby: Colby Community College, H. F. Davis Memorial Library (1968).  
 Emporia: Emporia State University, William Allen White Library (1909).  
 Fort Scott: Fort Scott Community College, Learning Resources Center Library (1979).  
 Hays: Fort Hays State University, Forsyth Library (1926).  
 Hutchinson: Hutchinson Public Library (1963).  
 Lawrence:  
   University of Kansas, Law Library (1971).  
   University of Kansas, Watson Library (1869)-REGIONAL.  
 Manhattan: Kansas State University, Farrell Library (1907).  
 Pittsburg: Pittsburg State University, Leonard H. Axe Library (1952).

Salina: Kansas Wesleyan University, Memorial Library (1930).  
 Shawnee Mission: Johnson County Library (1979).  
 Topeka:  
   Kansas State Historical Society Library (1877).  
   Kansas State Library (unknown).  
   Kansas Supreme Court Law Library (1975).  
   Washburn University of Topeka, Law Library (1971).  
 Wichita: Wichita State University Ablah Library (1901).

## KENTUCKY

Ashland: Boyd County Public Library (1946).  
 Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).  
 Bowling Green: Western Kentucky University, Helm-Cravens Graduate Center and Library (1934).  
 Danville: Centre College, Grace Doherty Library (1884).  
 Fort Mitchell: Thomas More College Library (1970).  
 Frankfort:  
   Kentucky Department of Libraries and Archives (1967).  
   Kentucky State Law Library (unknown).  
   Kentucky State University, Blazer Library (1972).  
 Highland Heights: Northern Kentucky University, W. Frank Steely Library (1973).  
 Hopkinsville: Hopkinsville Community College Library (1976).  
 Lexington:  
   University of Kentucky Law Library (1968).  
   University of Kentucky Libraries (1907)-REGIONAL.  
 Louisville:  
   Louisville Free Public Library (1904).  
   University of Louisville, Ekstrom Library (1925).  
   University of Louisville, Law Library (1975).  
 Morehead: Morehead State University, Camden-Carroll Library (1955).  
 Murray: Murray State University, Waterfield Library (1924).  
 Owensboro: Kentucky Wesleyan College Library Learning Center (1966).  
 Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

## LOUISIANA

Baton Rouge:  
   Louisiana State Library (1976).  
   Louisiana State University, Middleton Library (1907)-REGIONAL.  
   Louisiana State University, Paul M. Herbert Law Center Library (1929).  
   Louisiana State University Library (1907)-REGIONAL.  
   Southern University Law School Library (1979).  
   Southern University Library (1952).  
 Eunice: Louisiana State University at Eunice, LeDoux Library (1969).  
 Hammond: Southeastern Louisiana University, Sims Memorial Library (1966).  
 Lafayette: University of Southwestern Louisiana Library (1938).  
 Lake Charles: McNeese State University, Lether E. Frazar Memorial Library (1941).  
 Monroe: Northeast Louisiana University, Sandel Library (1963).  
 Natchitoches: Northwestern State University, Watson Memorial Library (1887).  
 New Orleans:  
   Law Library of Louisiana (unknown).  
   Loyola University Library (1942).  
   Loyola University, Law Library (1978).  
   New Orleans Public Library (1883).  
   Our Lady of Holy Cross College Library (1982).  
   Southern University in New Orleans Library (1962).  
   Tulane University, Howard-Tilton Memorial Library (1942).  
   Tulane University Law Library (1976).  
   University of New Orleans Earl K. Long Library (1963).  
   U.S. Court of Appeals, Fifth Circuit Library (1973).  
 Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).  
 Ruston: Louisiana Technical University, Prescott Memorial Library (1896)-REGIONAL.



**Shreveport:**

- Louisiana State University at Shreveport Library (1967).
- Shreve Memorial Library (1923).
- Thibodaux: Nicholls State University, Ellender Memorial Library (1962).

## MAINE

**Augusta:**

- Maine Law and Legislative Reference Library (1973).
- Maine State Library (unknown).
- Bangor: Bangor Public Library (1884).
- Brunswick: Bowdoin College Library (1884).
- Castine: Maine Maritime Academy, Nutting Memorial Library (1969).
- Lewiston: Bates College, George and Helen Ladd Library (1883).
- Orono: University of Maine, Raymond H. Fogler Library (1907)-REGIONAL.
- Portland:
- Portland Public Library (1884).
- University of Maine School of Law Library (1964).
- Presque Isle: University of Maine at Presque Isle, Library/Learning Resources Center (1979).
- Springvale: Nasson College Library (1961).
- Waterville: Colby College, Miller Library (1884).

## MARYLAND

**Annapolis:**

- Maryland State Law Library (unknown).
- U.S. Naval Academy, Nimitz Library (1895).
- Baltimore:
- Enoch Pratt Free Library (1887).
- Johns Hopkins University, Milton S. Eisenhower Library (1882).
- Morgan State College, Soper Library (1940).
- University of Baltimore, University Library (1973).
- University of Baltimore Law Library (1980).
- University of Maryland School of Law, Marshall Law Library (1969).
- Bel Air: Harford Community College Library (1967).
- Beltsville: Department of Agriculture, National Agricultural Library (1895).
- Bethesda: Department of Health and Human Services, National Library of Medicine (1978).
- Catonsville: University of Maryland, Baltimore County, University Library (1971).
- Chestertown: Washington College, Clifton M. Miller Library (1891).
- College Park: University of Maryland, McKeldin Library (1925)-REGIONAL.
- Cumberland: Allegany Community College Library (1974).
- Frostburg: Frostburg State College Library (1967).
- Patuxent River: U.S. Naval Air Station Library (1968).
- Rockville: Montgomery County Department of Public Libraries (1951).
- Salisbury: Salisbury State College, Blackwell Library (1965).
- Towson:
- Goucher College, Julia Rogers Library (1966).
- Towson State University, Cook Library (1979).
- Westminster: Western Maryland College, Hoover Library (1886).

## MASSACHUSETTS

**Amherst:**

- Amherst College Library (1884).
- University of Massachusetts, Goodell Library (1907).
- Belmont: Belmont Memorial Library (1968).
- Boston:
- Boston Athenaeum Library (unknown).
- Boston Public Library (1859)-REGIONAL.
- Boston University School of Law, Pappas Law Library (1979).
- Northeastern University Dodge Library (1962).
- State Library of Massachusetts (unknown).
- Suffolk University, Law Library (1979).
- Supreme Judicial Court, Social Law Library (1979).
- U.S. Court of Appeals, First Circuit Library (1978).
- Brookline: Public Library of Brookline (1925).

**Cambridge:**

- Harvard College Library (1860).
- Harvard Law School Library (1981).
- Massachusetts Institute of Technology Libraries (1946).
- Chestnut Hill: Boston College, Bapst Library (1963).
- Chicopee: College of Our Lady of the Elms, Alumnae Library (1969).
- Lowell: University of Lowell, Alumni-Lydon Library (1952).
- Lynn: Lynn Public Library (1953).
- Marlborough: Marlborough Public Library (1971).
- Medford: Tufts University Library (1899).
- Milton: Curry College Levin Library (1972).
- New Bedford: New Bedford Free Public Library (1858).
- Newton Centre: Boston College Law School Library (1979).
- North Dartmouth: Southeastern Massachusetts University Library (1965).
- North Easton: Stonehill College, Cushing-Martin Library (1962).
- Springfield:
- Springfield City Library (1966).
- Western New England College, Law Library (1978).
- Waltham: Brandeis University Library (1965).
- Wellesley: Wellesley College Library (1943).
- Wenham: Gordon College, Winn Library (1963).
- Williamstown: Williams College Library (unknown).
- Worcester:
- American Antiquarian Society Library (1814).
- University of Massachusetts Medical Center, Lamar Soutter Library (1972).
- Worcester Public Library (1859).

## MICHIGAN

- Albion: Albion College, Stockwell Memorial Library (1966).
- Allendale: Grand Valley State College, Zumberge Library (1963).
- Alma: Alma College Library (1963).
- Ann Arbor:
- University of Michigan, Harlan Hatcher Library (1884).
- University of Michigan, Law Library (1978).
- Benton Harbor: Benton Harbor Public Library (1907).
- Bloomfield Hills: Cranbrook Institute of Science Library (1940).
- Dearborn:
- Henry Ford Centennial Library (1969).
- Henry Ford Community College Library (1957).
- Detroit:
- Detroit College of Law Library (1979).
- Detroit Public Library (1868)-REGIONAL.
- Marygrove College Library (1965).
- Mercy College of Detroit Library (1965).
- University of Detroit Library (1884).
- University of Detroit, School of Law Library (1978).
- Wayne State University, G. Flint Purdy Library (1937).
- Wayne State University, Arthur Neef Law Library (1971).
- Dowagiac: Southwestern Michigan College, Matthews Library (1971).
- East Lansing: Michigan State University Library (1907).
- Farmington Hills: Oakland Community College, Martin L. King Learning Resources Center, (1968).
- Flint:
- Flint Public Library (1967).
- University of Michigan-Flint Library (1959).
- Grand Rapids:
- Calvin College & Seminary Library (1967).
- Grand Rapids Public Library (1876).
- Houghton: Michigan Technological University Library (1876).
- Jackson: Jackson District Library (1965).
- Kalamazoo:
- Kalamazoo Public Library (1907).
- Western Michigan University, Dwight B. Waldo Library (1963).
- Lansing:
- Michigan State Library (unknown)-REGIONAL.
- Thomas M. Cooley Law School Library (1978).
- Livonia: Schoolcraft College Library (1962).
- Madison Heights: Madison Heights Public Library (1982).
- Marquette: Northern Michigan University, Olson Library (1963).
- Monroe: Monroe County Library System (1974).
- Mt. Clemens: Macomb County Library (1968).
- Mt. Pleasant: Central Michigan University Library (1958).
- Muskegon: Hackley Public Library (1894).



Olivet: Olivet College Library (1974).  
 Petoskey: North Central Michigan College Library (1962).  
 Port Huron: Saint Clair County Library (1876).  
 Rochester: Oakland University, Kresge Library (1964).  
 Saginaw: Hoyt Public Library (1890).  
 Sault Ste. Marie: Lake Superior State College, Kenneth Shouldice Library (1982).  
 Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).  
 University Center: Delta College Learning Resources Center (1963).  
 Warren: Warren Public Library, Arthur J. Miller Branch (1973).  
 Wayne: Wayne Oakland Federated Library System (1957).  
 Ypsilanti: Eastern Michigan University Library (1965).

## MICRONESIA

Community College of Micronesia Library (1982).

## MINNESOTA

Bemidji: Bemidji State University, A. C. Clark Library (1963).  
 Collegeville: St. John's University, Alcuin Library (1954).  
 Duluth: Duluth Public Library (1909).  
 Mankato: Mankato State University, Memorial Library (1962).  
 Minneapolis:  
   Anoka County Library (1971).  
   Hennepin County Libraries (1971).  
   Minneapolis Public Library (1893).  
   University of Minnesota, Law School Library (1978).  
   University of Minnesota, Wilson Library (1907)-REGIONAL.  
 Moorhead: Moorhead State University Library (1956).  
 Morris: University of Minnesota, Morris, Rodney Briggs Library (1963).  
 Northfield:  
   Carleton College Library (1930).  
   St. Olaf College, Rolvaag Memorial Library (1930).  
 St. Cloud: St. Cloud State University, Learning Resources Center (1962).  
 St. Paul:  
   Hamline University, School of Law Library (1978).  
   Minnesota Historical Society Library (1867).  
   Minnesota State Law Library (unknown).  
   St. Paul Public Library (1914).  
   University of Minnesota, St. Paul Campus Library (1974).  
   William Mitchell College of Law Library (1979).  
 St. Peter: Gustavus Adolphus College Library (1941).  
 Stillwater: Stillwater Public Library (1893).  
 Willmar: Crow River Regional Library (1958).  
 Winona: Winona State University, Maxwell Library (1969).

## MISSISSIPPI

Cleveland: Delta State University, W. B. Roberts Library (1975).  
 Columbus: Mississippi State University for Women, John Clayton Fant Memorial Library (1929).  
 Hattiesburg: University of Southern Mississippi, Joseph A. Cook Memorial Library (1935).  
 Jackson:  
   Jackson State University, Henry Thomas Sampson Library (1968).  
   Millsaps College, Millsaps-Wilson Library (1963).  
   Mississippi College, School of Law Library (1977).  
   Mississippi Library Commission (1947).  
   Mississippi State Library (unknown).  
 Lorman: Alcorn State University Library (1970).  
 Mississippi State: Mississippi State University, Mitchell Memorial Library (1907).  
 University:  
   University of Mississippi Library (1833)-REGIONAL.  
   University of Mississippi, Law Library (1967).

## MISSOURI

Cape Girardeau: Southeast Missouri State University, Kent Library (1916).

Columbia:  
   University of Missouri at Columbia Library (1862).  
   University of Missouri-Columbia, Law Library (1978).  
 Fayette: Central Methodist College, George M. Smiley Library (1962).  
 Fulton: Westminster College, Reeves Library (1875).  
 Jefferson City:  
   Lincoln University, Inman E. Page Library (1944).  
   Missouri State Library (1963).  
   Missouri Supreme Court Library (unknown).  
 Joplin: Missouri Southern State College Library (1966).  
 Kansas City:  
   Kansas City Public Library (1881).  
   Rockhurst College, Greenlease Library (1917).  
   University of Missouri at Kansas City, General Library (1938).  
   University of Missouri-Kansas City, Leon E. Bloch Law Library (1978).  
 Kirksville: Northeast Missouri State University, Pickler Memorial Library (1966).  
 Liberty: William Jewell College, Charles F. Curry Library (1900).  
 Maryville: Northwest Missouri State University, Wells Library (1982).  
 Rolla: University of Missouri-Rolla, Curtis Laws Wilson Library (1907).  
 St. Charles: Lindenwood Colleges, Margaret Leggat Butler Library (1973).  
 St. Joseph: St. Joseph Public Library (1891).  
 St. Louis:  
   Maryville College Library (1976).  
   St. Louis County Library (1970).  
   St. Louis Public Library (1866).  
   St. Louis University Law Library (1967).  
   St. Louis University, Pius XII Memorial Library (1966).  
   University of Missouri at St. Louis, Thomas Jefferson Library (1966).  
   U.S. Court of Appeals, Eighth Circuit Library (1972).  
   Washington University, John M. Olin Library (1906).  
   Washington University Law Library (1978).  
 Springfield:  
   Drury College Walker Library (1874).  
   Southwest Missouri State University Library (1963).  
 Warrensburg: Central Missouri State University, Ward Edwards Library (1914).

## MONTANA

Billings: Eastern Montana College Library (1924).  
 Bozeman: Montana State University Renne Library (1907).  
 Butte: Montana College of Mineral Science and Technology Library (1901).  
 Havre: Northern Montana College Library (1980).  
 Helena:  
   Carroll College Library (1974).  
   Montana Historical Society Library (unknown).  
   Montana State Library (1966).  
   State Law Library of Montana (1977).  
 Missoula: University of Montana Maurene & Mike Mansfield Library (1909)-REGIONAL.

## NEBRASKA

Blair: Dana College, Dana-LIFE Library (1924).  
 Crete: Doane College, Perkins Library (1944).  
 Fremont: Midland Lutheran College Luther Library (1924).  
 Kearney: Kearney State College, Calvin T. Ryan Library (1962).  
 Lincoln:  
   Nebraska Library Commission (1972)-REGIONAL.  
   Nebraska State Library (unknown).  
   University of Nebraska-Lincoln, College of Law Library (1981).  
   University of Nebraska-Lincoln, D. L. Love Memorial Library (1907)-REGIONAL.  
 Omaha:  
   Creighton University, Alumni Memorial Library (1964).  
   Creighton University Law Library (1979).  
   Omaha Public Library, W. Dale Clark Library (1880).  
   University of Nebraska at Omaha, University Library (1939).



Scottsbluff: Scottsbluff Public Library (1925).  
Wayne: Wayne State College, U.S. Conn Library (1970).

## NEVADA

Carson City:  
Nevada State Library (unknown).  
Nevada Supreme Court Library (1973).  
Las Vegas:  
Clark County Library District (1974).  
University of Nevada at Las Vegas, James Dickinson Library (1959).  
Reno:  
National Judicial College, Law Library (1979).  
Nevada Historical Society Library (1974).  
University of Nevada Library (1907)-REGIONAL.  
Washoe County Library (1980).

## NEW HAMPSHIRE

Concord:  
Franklin Pierce Law Center Library (1973).  
New Hampshire State Library (unknown).  
Durham: University of New Hampshire Library (1907).  
Hanover: Dartmouth College Library (1884).  
Henniker: New England College Danforth Library (1966).  
Manchester:  
Manchester City Library (1884).  
New Hampshire College, H. A. B. Shapiro Memorial Library (1976).  
St. Anselm's College, Geisel Library (1963).  
Nashua: Nashua Public Library (1971).

## NEW JERSEY

Bayonne: Bayonne Free Public Library (1909).  
Bloomfield: Bloomfield Public Library (1965).  
Bridgeton: Cumberland County Library (1966).  
Camden:  
Rutgers University, Camden Library (1966).  
Rutgers University, School of Law Library (1979).  
Convent Station: College of St. Elizabeth, Mahoney Library (1938).  
East Brunswick: East Brunswick Public Library (1977).  
East Orange: East Orange Public Library (1966).  
Elizabeth: Free Public Library of Elizabeth (1895).  
Glassboro: Glassboro State College, Savitz Learning Resource Center (1963).  
Hackensack: Johnson Free Public Library (1966).  
Irvington: Free Public Library of Irvington (1966).  
Jersey City:  
Jersey City Public Library (1879).  
Jersey City State College, Forrest A. Irwin Library (1963).  
Lawrenceville: Rider College, Franklin F. Moore Library (1975).  
Madison: Drew University, Rose Memorial Library (1939).  
Mahwah: Ramapo College Library (1971).  
Mount Holly: Burlington County Library (1966).  
New Brunswick:  
New Brunswick Free Public Library (1908).  
Rutgers University Alexander Library (1907).  
Newark:  
Newark Public Library (1906)-REGIONAL.  
Rutgers, The State University, John Cotton Dana Library (1966).  
Rutgers, The State University, Law School, Newark, Justice Henry E. Ackerson Law Library (1979).  
Seton Hall University School of Law Library (1979).  
Passaic: Passaic Public Library (1964).  
Pemberton: Burlington County College Library (1979).  
Phillipsburg: Phillipsburg Free Public Library (1976).  
Plainfield: Plainfield Public Library (1971).  
Pomona: Stockton State College Library (1972).  
Princeton: Princeton University Library (1884).  
Randolph Township: County College of Morris Sherman H. Masten Learning Resource Center (1975).  
Rutherford: Fairleigh Dickinson University, Messler Library (1953).  
Shrewsbury: Monmouth County Library (1968).

South Orange: Seton Hall University, McLaughlin Library (1947).  
Teaneck: Fairleigh Dickinson University, Teaneck/Hackensack Campus Library (1963).  
Toms River: Ocean County College, Learning Resources Center (1966).  
Trenton:  
New Jersey State Library (unknown).  
Trenton Free Public Library (1902).  
Union: Kean College of New Jersey, Nancy Thompson Library (1973).  
Upper Montclair: Montclair State College, Harry S. Sprague Library (1967).  
Wayne: Wayne Public Library (1972).  
West Long Beach: Monmouth College, Guggenheim Memorial Library (1963).  
Woodbridge: Free Public Library of Woodbridge (1965).

## NEW MEXICO

Albuquerque:  
University of New Mexico, Medical Center Library (1973).  
University of New Mexico, School of Law Library (1973).  
University of New Mexico, General Library (1896)-REGIONAL.  
AL.  
Hobbs: New Mexico Junior College, Pannell Library (1969).  
Las Cruces: New Mexico State University Library (1907).  
Las Vegas: New Mexico Highlands University, Donnelly Library (1913).  
Portales: Eastern New Mexico University, Golden Library (1962).  
Santa Fe:  
New Mexico State Library (1960)-REGIONAL.  
New Mexico Supreme Court Law Library (unknown).  
Silver City: Western New Mexico University, Miller Library (1972).

## NEW YORK

Albany:  
Albany Law School Library (1979).  
New York State Library (unknown)-REGIONAL.  
State University of New York at Albany, University Library (1964).  
Auburn: Seymour Library (1972).  
Bayside: Queensborough Community College Library (1972).  
Binghamton: State University of New York at Binghamton, Glenn G. Bartle Library (1962).  
Brockport: State University of New York at Brockport, Drake Memorial Library (1967).  
Bronx:  
Fordham University Library (1937).  
Herbert H. Lehman College Library (1967).  
New York Public Library, Mott Haven Branch (1973).  
State University of New York, Maritime College, Stephen B. Luce Library (1947).  
Brooklyn:  
Brooklyn College Library (1936).  
Brooklyn Law School Library (1974).  
Brooklyn Public Library (1908).  
Polytechnic Institute of New York, Spicer Library (1963).  
Pratt Institute Library (1891).  
State University of New York, Downstate Medical Center Library (1958).  
Buffalo:  
Buffalo and Erie County Public Library (1895).  
State University of New York at Buffalo, Charles B. Sears Law Library (1978).  
State University of New York at Buffalo, Lockwood Memorial Library (1963).  
Canton: St. Lawrence University, Owen D. Young Library (1920).  
Cheektowaga: Cheektowaga Public Library, Reinstein Memorial Branch (1978).  
Corning: Corning Community College, Arthur A. Houghton, Jr., Library (1963).  
Cortland: State University of New York at Cortland, Memorial Library (1964).  
Delhi: State University Agricultural and Technical College Library (1970).



Douglaston: Cathedral College Library (1971).  
 East Islip: East Islip Public Library (1973).  
 Elmira: Elmira College, Gannett Tripp Learning Center (1956).  
 Farmingdale: State University of New York at Farmingdale Library (1917).  
 Flushing: Queens College, Paul Klapper Library (1939).  
 Garden City: Adelphi University, Swirbul Library (1966).  
 Geneseo: State University of New York at Geneseo, Milne Library (1967).  
 Greenvale: Long Island University, B. Davis Schwartz Memorial Library (1964).  
 Hamilton: Colgate University, Everett Needham Case Library (1902).  
 Hempstead:  
   Hofstra University Library (1964).  
   Hofstra University, School of Law Library (1979).  
 Ithaca:  
   Cornell University Library (1907).  
   Cornell Law Library (1978).  
   New York State College of Agriculture and Human Economics, Albert R. Mann Library (1943).  
 Jamaica:  
   Queens Borough Public Library (1926).  
   St. John's University Library (1956).  
   St. John's University, School of Law Library (1978).  
 Kings Point: U.S. Merchant Marine Academy Library (1962).  
 Long Island City: Fiorello H. LaGuardia Community College Library (1981).  
 Mount Vernon: Mount Vernon Public Library (1962).  
 New Paltz: State University College at New Paltz, Sojourner Truth Library (1965).  
 New York City:  
   Cardoza Law School Library (1979).  
   City University of New York, City College Library (1884).  
   College of Insurance Library (1965).  
   Columbia University Libraries (1882).  
   Columbia University, School of Law Library (1981).  
   Cooper Union for the Advancement of Science and Arts Library (1930).  
   Medical Library Center of New York (1976).  
   New York Law Institute Library (1909).  
   New York Law School Library (1979).  
   New York Public Library, Astor Branch (1907).  
   New York Public Library, Lenox Branch (1884).  
   New York University Law Library (1902).  
   New York University, Elmer Holmes Bobst Library (1967).  
   U.S. Court of Appeals, Second Circuit Library (1976).  
   Yeshiva University, Pollack Library (1979).  
 Newburgh: Newburgh Free Library (1909).  
 Niagara Falls: Niagara Falls Public Library (1976).  
 Oakdale: Dowling College Library (1965).  
 Oneonta: State University College at Oneonta, James M. Milne Library (1966).  
 Oswego: State University College at Oswego, Penfield Library (1966).  
 Plattsburgh: State University College at Plattsburgh, Benjamin F. Feinberg Library (1967).  
 Potsdam:  
   Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).  
   State University College at Potsdam, Frederick W. Crumb Memorial Library (1964).  
 Poughkeepsie: Vassar College Library (1943).  
 Purchase: State University of New York, College at Purchase Library (1969).  
 Rochester:  
   Rochester Public Library (1963).  
   University of Rochester Rush Rhees Library (1880).  
 St. Bonaventure: St. Bonaventure University, Friedsam Memorial Library (1938).  
 Saratoga Springs: Skidmore College Library (1964).  
 Schenectady: Union College, Schaffer Library (1901).  
 Southampton: Southampton College Library (1973).  
 Staten Island: Wagner College, Horrmann Library, Grymes Hill (1953).  
 Stony Brook: State University of New York at Stony Brook, Main Library (1963).

#### Syracuse:

Onondaga County Public Library (1978).  
 Syracuse University Library (1878).  
 Syracuse University, William C. Ruger Law Library (1978).  
 Troy: Troy Public Library (1869).  
 Uniondale: Nassau Library System (1965).  
 Utica:  
   Utica Public Library (1885).  
   SUNY College of Technology Library (1977).  
 West Point: U.S. Military Academy Cadet Library (unknown).  
 White Plains: Pace University, Law School Library (1978).  
 Yonkers:  
   Sarah Lawrence College Library (1969).  
   Yonkers Public Library (1910).  
 Yorktown Heights: Mercy College Library (1976).

## NORTH CAROLINA

Asheville: University of North Carolina, D. Hiden Ramsey Library (1965).  
 Boiling Springs: Gardner-Webb College, Dover Memorial Library (1974).  
 Boone: Appalachian State University Library (1963).  
 Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).  
 Chapel Hill:  
   University of North Carolina at Chapel Hill, Wilson Library (1884)-REGIONAL.  
   University of North Carolina Law Library (1978).  
 Charlotte:  
   Public Library of Charlotte and Mecklenburg County (1964).  
   Queens College, Everett Library (1927).  
   University of North Carolina at Charlotte, Atkins Library (1964).  
 Cullowhee: Western Carolina University, Hunter Library (1953).  
 Davidson: Davidson College Library (1893).  
 Durham:  
   Duke University, School of Law Library (1978).  
   Duke University, William R. Perkins Library (1890).  
   North Carolina Central University, Law Library (1979).  
   North Carolina Central University, James E. Shepard Memorial Library (1973).  
 Elon College: Iris Holt McEwen Library (1971).  
 Fayetteville: Fayetteville State University, Charles W. Chestnutt Library (1971).  
 Greensboro:  
   North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).  
   University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).  
 Greenville: East Carolina University, J. Y. Joyner Library (1951).  
 Laurinburg: St. Andrews Presbyterian College, DeTamble Library (1969).  
 Lexington: Davidson County Public Library (1971).  
 Mount Olive: Mount Olive College, Moye Library (1971).  
 Murfreesboro: Chowan College, Whitaker Library (1963).  
 Pembroke: Pembroke State University, Mary H. Livermore Library (1956).  
 Raleigh:  
   Department of Cultural Resources, Division of State Library (unknown).  
   North Carolina State University, D. H. Hill Library (1923).  
   North Carolina Supreme Court Library (1972).  
   Wake County Public Library (1969).  
 Rocky Mount: North Carolina Wesleyan College Library (1969).  
 Salisbury: Catawba College Library (1925).  
 Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).  
 Wilson: Atlantic Christian College, Clarence L. Hardy Library (1930).  
 Winston-Salem:  
   Forsyth County Public Library (1954).  
   Wake Forest University, Z. Smith Reynolds Library (1902).



## NORTH DAKOTA

### Bismarck:

- North Dakota State Library (1971).
- North Dakota Supreme Court Law Library (unknown).
- State Historical Society of North Dakota Library (1907).
- Veterans' Memorial Public Library (1967).

Dickinson: Dickinson State College, Stoxen Library (1968).

### Fargo:

- Fargo Public Library (1964).
- North Dakota State University Library (1907)-REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library.

Grand Forks: University of North Dakota, Chester Fritz Library (1890).

Minot: Minot State College, Memorial Library (1925).

Valley City: Valley City State College Library (1913).

Portsmouth: Portsmouth Public Library (unknown).

Rio Grande: Rio Grande College and Community College, Jeanette Albiez Davis Library (1966).

Springfield: Warder Public Library (1884).

### Steubenville:

- Public Library of Steubenville and Jefferson County (1950).
- College of Steubenville, Starvaggi Memorial Library (1971).

Tiffin: Heidelberg College, Beeghly Library (1964).

### Toledo:

- Toledo-Lucas County Public Library (1884).
- University of Toledo, College of Law Library (1981).
- University of Toledo Library (1963).

Westerville: Otterbein College Courtright Memorial Library (1967).

Wooster: College of Wooster, Andrews Library (1966).

### Youngstown:

- Public Library of Youngstown and Mahoning County (1923).
- Youngstown State University, William F. Maag Library (1971).

## OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).

### Akron:

- Akron-Summit Public Library (1952).
- University of Akron, Bierce Library (1963).
- University of Akron, C. Blake McDowell Law Center, School of Law Library (1978).

Alliance: Mount Union College Library (1888).

Ashland: Ashland College Library (1938).

Athens: Ohio University Library (1886).

Batavia: University of Cincinnati at Batavia, Clermont General and Technical College Library (1973).

Bluffton: Bluffton College, Musselman Library (1951).

Bowling Green: Bowling Green State University Library (1933).

Canton: Malone College, Everett L. Cattell Library (1970).

Chardon: Geauga County Public Library (1971).

### Cincinnati:

- Public Library of Cincinnati and Hamilton County (1884).
- University of Cincinnati, Central Library (1929).
- University of Cincinnati, College of Law, Marx Law Library (1978).

### Cleveland:

- Case Western Reserve University, Freiburger Library (1913).
- Case Western Reserve University, School of Law Library (1979).
- Cleveland Heights-University Heights Public Library (1970).
- Cleveland Public Library (1886).
- Cleveland State University, Cleveland-Marshall College of Law, Joseph W. Bartunek III Law Library (1978).
- Cleveland State University Library (1966).
- John Carroll University, Grasselli Library (1963).
- Municipal Reference Library (1970).

### Columbus:

- Capital University Law School Library (1980).
- Capital University Library (1968).
- Ohio State University Libraries (1907).
- Ohio Supreme Court Law Library (1973).
- Public Library of Columbus and Franklin County (1885).
- State Library of Ohio (unknown)-REGIONAL.

### Dayton:

- Dayton and Montgomery County Public Library (1909).
- University of Dayton, Roesch Library (1969).
- Wright State University Library (1965).

Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).

Elyria: Elyria Public Library (1966).

Findlay: Findlay College, Shafer Library (1969).

Gambier: Kenyon College Library (1873).

Granville: Denison University Libraries, William H. Doane Library (1884).

Hiram: Hiram College, Teachout-Price Memorial Library (1874).

Kent: Kent State University Libraries (1962).

Marietta: Marietta College, Dawes Memorial Library (1884).

Marion: Marion Public Library (1979).

Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).

New Concord: Muskingum College Library (1966).

Oberlin: Oberlin College Library (1858).

Oxford: Miami University at Oxford, King Library (1909).

## OKLAHOMA

Ada: East Central Oklahoma State University, Linscheid Library (1914).

Alva: Northwestern Oklahoma State University Library (1907).

Bartlesville: U.S. Department of Energy, Bartlesville Energy Research Center Library (1962).

Bethany: Bethany Nazarene College, R. T. Williams Library (1971).

Durant: Southeastern Oklahoma State University Library (1929).

Edmond: Central State University Library (1934).

Enid: Public Library of Enid and Garfield County (1908).

Langston: Langston University, G. Lamar Harrison Library (1941).

Muskogee: Muskogee Public Library (1971).

### Norman:

- University of Oklahoma Libraries, Bizzell Memorial Library (1893).
- University of Oklahoma, Law Library (1978).

### Oklahoma City:

- Metropolitan Library System (1974).
- Oklahoma City University Library (1963).
- Oklahoma Department of Libraries (1893)-REGIONAL.

Shawnee: Oklahoma Baptist University Library (1933).

Stillwater: Oklahoma State University Library (1907)-REGIONAL.

Tahlequah: Northeastern Oklahoma State University, John Vaughan Library (1923).

### Tulsa:

- Tulsa City-County Library System (1963).
- University of Tulsa College of Law Library (1979).
- University of Tulsa, McFarlin Library (1929).

Weatherford: Southwestern Oklahoma State University, Al Harris Library (1958).

## OREGON

Ashland: Southern Oregon State College Library (1953).

Corvallis: Oregon State University Library (1907).

### Eugene:

- University of Oregon Law Library (1979).
- University of Oregon Library (1883).

Forest Grove: Pacific University, Harvey W. Scott Library (1897).

Klamath Falls: Oregon Institute of Technology, Learning and Resources Center (1982).

La Grande: Eastern Oregon College, Walter M. Pierce Library (1954).

McMinnville: Linfield College, Northup Library (1965).

Monmouth: Western Oregon State College Library (1967).

### Portland:

- Lewis and Clark College, Aubrey R. Watzek Library (1967).
- Library Association of Portland (1884).
- Northwestern School of Law, Paul L. Boley Law Library (1979).
- Portland State University Library (1963)-REGIONAL.
- Reed College Library (1912).
- U.S. Department of Energy, Bonneville Power Administration Library (1962).

### Salem:

- Oregon State Library (unknown).
- Oregon Supreme Court Library (1974).



Willamette University, College of Law Library (1979).  
Willamette University, Main Library (1969).

## PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).  
Altoona: Altoona Area Public Library (1969).  
Bethel Park: Bethel Park Public Library (1980).  
Bethlehem: Lehigh University Libraries, Linderman Library (1876).  
Blue Bell: Montgomery County Community College, Learning Resources Center (1975).  
Bradford: University of Pittsburgh at Bradford (1979).  
Carlisle:  
    Dickinson College, Boyd Lee Spahr Library (1947).  
    Dickinson School of Law, Sheeley-Lee Law Library (1978).  
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1967).  
Collegeville: Ursinus College, Myrin Library (1963).  
Coraopolis: Robert Morris College Library (1978).  
Doylestown: Bucks County Free Library (1970).  
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).  
Erie: Erie County Library System (1897).  
Greenville: Thiel College, Langenheim Memorial Library (1963).  
Harrisburg: State Library of Pennsylvania (unknown)-REGIONAL.  
Haverford: Haverford College, Magill Library (1897).  
Hazleton: Hazleton Area Public Library (1964).  
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).  
Johnstown: Cambria County Library System (1965).  
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).  
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).  
Mansfield: Mansfield State College Library (1968).  
Meadville: Allegheny College, Lawrence Lee Pelletier Library (1907).  
Millersville: Millersville State College, Helen A. Ganser Library (1966).  
Monessen: Monessen Public Library (1969).  
New Castle: New Castle Public Library (1963).  
Newtown: Bucks County Community College Library (1968).  
Norristown: Montgomery County-Norristown Public Library (1969).  
Philadelphia:  
    Drexel University Library (1963).  
    Free Library of Philadelphia (1897).  
    St. Joseph's University, Drexel Library (1974).  
    Temple University, Paley Library (1947).  
    Temple University Law Library (1979).  
    Thomas Jefferson University, Scott Memorial Library (1978).  
    U.S. Court of Appeals, Third Circuit Library (1973).  
    University of Pennsylvania, Biddle Law Library (1974).  
    University of Pennsylvania Library (1886).  
Pittsburgh:  
    Allegheny County Law Library (1977).  
    Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).  
    Carnegie Library of Pittsburgh (1895).  
    Duquesne University Law Library (1978).  
    La Roche College, John J. Wright Library (1974).  
    University of Pittsburgh, Hillman Library (1910).  
    University of Pittsburgh Law Library (1979).  
    U.S. Department of Interior, Bureau of Mines Library (1962).  
Pottsville: Pottsville Free Public Library (1967).  
Reading: Reading Public Library (1901).  
Scranton: Scranton Public Library (1895).  
Shippensburg: Shippensburg State College, Ezra Lehman Memorial Library (1973).  
Slippery Rock: Slippery Rock State College, Bailey Library (1965).  
Swarthmore: Swarthmore College Library (1923).  
University Park: Pennsylvania State University Libraries (1907).  
Villanova: Villanova University Law School, Pulling Law Library (1964).  
Warren: Warren Library Association, Warren Public Library (1885).  
Washington: Washington and Jefferson College, U. Grant Miller Library (1884).  
Waynesburg: Waynesburg College Library (1964).

West Chester: West Chester State College, Francis Harvey Green Library (1967).

Wilkes-Barre: King's College, D. Leonard Corgan Library (1949).  
Williamsport: Lycoming College Library (1970).  
York: York College of Pennsylvania, Schmidt Library (1963).  
Youngwood: Westmoreland County Community College, Learning Resources Center (1972).

## PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).  
Ponce:  
    Catholic University of Puerto Rico, Encarnacion Valdes Library (1966).  
    Catholic University of Puerto Rico, School of Law Library (1978).  
Rio Piedras: University of Puerto Rico, General Library (1928).

## RHODE ISLAND

Kingston: University of Rhode Island Library (1907).  
Newport: U.S. Naval War College Library (1963).  
Providence:  
    Brown University, John D. Rockefeller, Jr. Library (unknown).  
    Providence College, Phillips Memorial Library (1969).  
    Providence Public Library (1884).  
    Rhode Island College, James P. Adams Library (1965).  
    Rhode Island State Law Library (1979).  
    Rhode Island State Library (before 1895).  
Warwick: Warwick Public Library (1966).  
Westerly: Westerly Public Library (1909).  
Woonsocket: Woonsocket Harris Public Library (1977).

## SOUTH CAROLINA

Charleston:  
    Baptist College at Charleston, L. Mendel Rivers Library (1967).  
    The Citadel, Daniel Library (1962).  
    College of Charleston, Robert Scott Small Library (1869).  
Clemson: Clemson University Library (1893).  
Columbia:  
    Benedict College, Payton Learning Resources Center (1969).  
    Richland County Public Library (1978).  
    South Carolina State Library (before 1895).  
    University of South Carolina, Thomas Cooper Library (1884).  
Conway: University of South Carolina, Coastal Carolina College, Kimbel Library (1974).  
Due West: Erskine College, McCain Library (1968).  
Florence:  
    Florence County Library (1967).  
    Francis Marion College, James A. Rogers Library (1970).  
Greenville:  
    Furman University Library (1962).  
    Greenville County Library (1966).  
Greenwood: Lander College, Larry A. Jackson Library (1967).  
Orangeburg: South Carolina State College, Miller F. Whittaker Library (1953).  
Rock Hill: Winthrop College, Dacus Library (1896).  
Spartanburg: Spartanburg County Public Library (1967).

## SOUTH DAKOTA

Aberdeen: Northern State College Library (1963).  
Brookings: South Dakota State University, H. M. Briggs Library (1889).  
Pierre:  
    South Dakota State Library (1973).  
    South Dakota Supreme Court Library (1978).  
Rapid City:  
    Rapid City Public Library (1963).  
    South Dakota School of Mines and Technology (1963).



#### Sioux Falls:

Augustana College, Mikkelsen Library and Learning Resource Center (1969).

Sioux Falls Public Library (1903).

Spearfish: Black Hills State College Library Learning Center (1942).

Vermillion: University of South Dakota, I. D. Weeks Library (1889).

Yankton: Yankton College, James Lloyd Library (1904).

## TENNESSEE

Bristol: King College, E. W. King Library (1970).

#### Chattanooga:

Chattanooga-Hamilton County Bicentennial Library (1908).

U.S. Tennessee Valley Authority Technical Library (1976).

Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).

Cleveland: Cleveland State Community College Library (1973).

Columbia: Columbia State Community College, John W. Finney Memorial Library (1973).

Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).

Jackson: Lambuth College, Luther L. Gobbel Library (1967).

Jefferson City: Carson-Newman College Library (1964).

Johnson City: East Tennessee State University, Sherrod Library (1942).

#### Knoxville:

Public Libraries Knoxville-Knox County, Lawson McGhee Library (1973).

University of Tennessee at Knoxville, James D. Hoskins Library (1907).

University of Tennessee Law Library (1971).

Martin: University of Tennessee at Martin, Paul Meek Library (1957).

#### Memphis:

Memphis-Shelby County Public Library and Information Center (1896).

Memphis State University, Cecil C. Humphreys School of Law Library (1979).

Memphis State University, John W. Brister Library (1966).

Murfreesboro: Middle Tennessee State University, Todd Library (1912).

#### Nashville:

Fisk University Library (1965).

Public Library of Nashville and Davidson County (1884).

Tennessee State Law Library (1976).

Tennessee State Library and Archives (unknown).

Tennessee State University, Brown-Daniel Library (1972).

Vanderbilt University Law Library (1976).

Vanderbilt University Library (1884).

Sewanee: University of the South, Jesse Ball duPont Library (1873).

## TEXAS

#### Abilene:

Abilene Christian University, Margaret and Herman Brown Library (1978).

Hardin-Simmons University, Rupert and Pauline Richardson Library (1940).

#### Arlington:

Arlington Public Library (1970).

University of Texas at Arlington Library (1963).

#### Austin:

Texas State Law Library (1972).

Texas State Library (unknown)-REGIONAL.

University of Texas at Austin, Perry-Castaneda Library (1884).

University of Texas at Austin, Lyndon B. Johnson School of Public Affairs Library (1966).

University of Texas at Austin, Tarlton Law Library (1965).

Baytown: Lee College Library (1970).

Beaumont: Lamar University, Mary and John Gray Library (1957).

Brownwood: Howard Payne University, Walker Memorial Library (1964).

Canyon: West Texas State University, Cornett Library (1928).

College Station: Texas Agricultural and Mechanical University Library (1907).

Commerce: East Texas State University Library (1937).

Corpus Christi: Corpus Christi State University Library (1976).

Corsicana: Navarro College, Gaston T. Gooch Library (1965).

#### Dallas:

Bishop College, Zale Library (1966).

Dallas Baptist College, Vance Memorial Library (1967).

Dallas Public Library (1900).

Southern Methodist University, Fondren Library (1925).

University of Texas Health Science Center-Dallas Library (1975).

Denton: North Texas State University Library (1948).

Edinburg: Pan American University Library (1959).

#### El Paso:

El Paso Public Library (1906).

University of Texas at El Paso Library (1966).

#### Fort Worth:

Fort Worth Public Library (1905).

Texas Christian University, Mary Coats Burnett Library (1916).

Galveston: Rosenberg Library (1909).

#### Houston:

Houston Public Library (1884).

North Harris County College, Learning Resource Center (1974).

Rice University, Fondren Library (1967).

South Texas College of Law Library (1981).

University of Houston at Clear Lake City Library (1980).

University of Houston Library (1957).

University of Houston, School of Law Library (1979).

Huntsville: Sam Houston State University Library (1949).

Irving: Irving Public Library System (1974).

Kingsville: Texas Arts and Industries University, Jernigan Library (1944).

Laredo: Laredo Junior College, Harold R. Yeary Library (1970).

Longview: Nicholson Memorial Public Library (1961).

#### Lubbock:

Texas Tech University Library (1935)-REGIONAL.

Texas Tech University, School of Law Library (1978).

Marshall: Wiley College, Thomas Winston Cole, Sr. Library (1962).

Nacogdoches: Stephen F. Austin State University, Steen Library (1965).

Plainview: Wayland Baptist University, Van Howeling Memorial Library (1963).

Richardson: University of Texas at Dallas Library (1972).

San Angelo: Angelo State University, Porter Henderson Library (1964).

#### San Antonio:

San Antonio College Library (1972).

San Antonio Public Library, (1899).

St. Mary's University, Academic Library (1964).

Trinity University Library (1964).

University of Texas at San Antonio Library (1973).

San Marcos: Southwest Texas State University Library (1955).

Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).

Sherman: Austin College, Arthur Hopkins Library (1963).

Texarkana: Texarkana Community College, Palmer Memorial Library (1963).

Victoria: Victoria College/University of Houston, Victoria Campus Library (1973).

Waco: Baylor University, Moody Memorial Library (1905).

Wichita Falls: Midwestern University, Moffett Library, (1963).

## UTAH

Cedar City: Southern Utah State College Library (1964).

Ephraim: Snow College, Lucy A. Phillips Library (1963).

Logan: Utah State University, Merrill Library and Learning Resources Center (1907)-REGIONAL.

Ogden: Weber State College, Stewart Library (1962).

#### Provo:

Brigham Young University, Harold B. Lee Library (1908).

Brigham Young University, J. Reuben Clark Law Library (1972).

#### Salt Lake City:

University of Utah, Eccles Health Sciences Library (1970).

University of Utah, Law Library (1966).

University of Utah, Marriott Library (1893).

Utah State Library (unknown).

Utah State Supreme Court, Law Library (1975).



## VERMONT

Burlington: University of Vermont, Bailey Library (1907).  
Castleton: Castleton State College, Calvin Coolidge Library (1969).  
Johnson: Johnson State College, John Dewey Library (1955).  
Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).  
Middlebury: Middlebury College, Egbert Starr Library (1884).  
Montpelier: Vermont Department of Libraries (before 1895).  
Northfield: Norwich University Library (1908).  
South Royalton: Vermont Law School Library (1978).

## VIRGIN ISLANDS

St. Croix: Florence Williams Public Library (1974).  
St. Thomas:  
College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).  
Enid M. Baa Library and Archives (1968).

## VIRGINIA

Alexandria: Dept. of the Navy, General Law Library (1963).  
Arlington: George Mason University School of Law Library (1981).  
Blacksburg: Virginia Polytechnic Institute and State University, Carol M. Newman Library (1907).  
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).  
Charlottesville:  
University of Virginia, Alderman Library (1910)-REGIONAL.  
University of Virginia Law School, Arthur J. Morris Law Library (1964).  
Chesapeake: Chesapeake Public Library (1970).  
Danville: Danville Community College, Learning Resources Center (1969).  
Emory: Emory and Henry College, Kelly Library (1884).  
Fairfax: George Mason University, Fenwick Library (1960).  
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).  
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).  
Hampton: Hampton Institute, Huntington Memorial Library (1977).  
Harrisonburg: James Madison University, Madison Memorial Library (1973).  
Hollins College: Hollins College, Fishburn Library (1967).  
Lexington:  
Virginia Military Institute, Preston Library (1874).  
Washington and Lee University, University Library (1910).  
Washington and Lee University, Wilbur C. Hall Law Library (1978).  
Martinsville: Patrick Henry Community College Library (1971).  
Norfolk:  
Norfolk Public Library (1895).  
Old Dominion University Library (1963).  
U.S. Armed Forces Staff College Library (1963).  
Petersburg: Virginia State University, Johnston Memorial Library (1907).  
Quantico:  
Federal Bureau of Investigation, Academy Library (1970).  
U.S. Marine Corps Schools, James Carson Breckinridge Library (1967).  
Reston: Department of the Interior, Geological Survey, National Center Library (1962).  
Richmond:  
University of Richmond, Boatwright Memorial Library (1900).  
University of Richmond, Law School Library (1982).  
U.S. Court of Appeals, Fourth Circuit Library (1973).  
Virginia Commonwealth University, James Branch Cabell Library (1971).  
Virginia State Law Library (1973).  
Virginia State Library (unknown).  
Roanoke: Roanoke Public Library (1964).  
Salem: Roanoke College Library (1886).

Williamsburg:

College of William and Mary, Marshall-Wythe Law Library (1978).

College of William and Mary, Swem Library (1936).

Wise: Clinch Valley College, John Cook Wyllie Library (1971).

## WASHINGTON

Bellingham: Western Washington University, Mabel Zoe Wilson Library (1963).  
Cheney: Eastern Washington University, JFK Library (1966).  
Ellensburg: Central Washington University Library (1962).  
Everett: Everett Public Library (1914).  
Olympia:  
Evergreen State College, Daniel J. Evans Library (1972).  
Washington State Law Library (1979).  
Washington State Library (unknown)-REGIONAL.  
Port Angeles: North Olympic Library System (1965).  
Pullman: Washington State University Library (1907).  
Seattle:  
Seattle Public Library (1908).  
University of Washington Libraries (1890).  
University of Washington, Mary Gould Gallagher Law Library (1969).  
U.S. Court of Appeals, 9th Circuit Library (1981).  
Spokane:  
Gonzaga University, School of Law Library (1979).  
Spokane Public Library (1910).  
Tacoma:  
Tacoma Public Library (1894).  
University of Puget Sound, Collins Memorial Library (1938).  
University of Puget Sound, School of Law Library (1978).  
Vancouver: Fort Vancouver Regional Library (1962).  
Walla Walla: Whitman College, Penrose Memorial Library (1890).

## WEST VIRGINIA

Athens: Concord College Library (1924).  
Bluefield: Bluefield State College, Hardway Library (1972).  
Charleston:  
Kanawha County Public Library (1952).  
West Virginia Library Commission (unknown).  
West Virginia Supreme Court Law Library (1977).  
Elkins: Davis and Elkins College Library (1913).  
Fairmont: Fairmont State College Library (1884).  
Glenville: Glenville State College, Robert F. Kidd Library (1966).  
Huntington: Marshall University, James E. Morrow Library (1925).  
Institute: West Virginia State College, Drain-Jordan Library (1907).  
Morgantown: West Virginia University Library (1907)-REGIONAL.  
Salem: Salem College Library (1921).  
Shepherdstown: Shepherd College, Ruth Scarborough Library (1971).  
Weirton: Mary H. Weir Public Library (1963).

## WISCONSIN

Appleton: Lawrence University, Seeley G. Mudd Library (1869).  
Beloit: Beloit College, Col. Robert H. Morse Library (1888).  
Eau Claire: University of Wisconsin-Eau Claire, William D. McIntyre Library (1951).  
Fond du Lac: Fond du Lac Public Library (1966).  
Green Bay: University of Wisconsin-Green Bay, Library Learning Center (1968).  
La Crosse:  
La Crosse Public Library (1883).  
University of Wisconsin-La Crosse, Murphy Library (1965).  
Madison:  
Madison Public Library (1965).  
State Historical Society Library (1870)-REGIONAL, in cooperation with University of Wisconsin-Madison, Memorial Library.  
University of Wisconsin-Madison Law Library (1981).  
University of Wisconsin-Madison, Memorial Library (1939).  
Wisconsin State Law Library (unknown).  
Milwaukee:  
Alverno College Library/Media Center (1971).



Medical College of Wisconsin, Inc., Todd Wehr Library (1980).  
 Milwaukee County Law Library (1934).  
 Milwaukee Public Library (1861)-REGIONAL.  
 Mount Mary College Library (1964).  
 University of Wisconsin-Milwaukee Library (1960).  
 Oshkosh: University of Wisconsin-Oshkosh, Forrest R. Polk Library  
 (1956).  
 Platteville: University of Wisconsin-Platteville, Karrmann Library  
 (1964).  
 Racine: Racine Public Library (1898).  
 Ripon: Ripon College Library (1982).  
 River Falls: University of Wisconsin-River Falls, Chalmer Davee Li-  
 brary (1962).  
 Stevens Point: University of Wisconsin-Stevens Point, Learning  
 Resources Center (1951).  
 Superior:  
     Superior Public Library (1908).  
     University of Wisconsin-Superior, Jim Dan Hill Library (1935).  
 Waukesha: Waukesha Public Library (1966).  
 Wausau: Marathon County Public Library (1971).  
 Whitewater: University of Wisconsin-Whitewater, Harold Anderson  
 Library (1963).

## WYOMING

Casper: Natrona County Public Library (1929).  
 Cheyenne:  
     Wyoming State Law Library (1977).  
     Wyoming State Library (unknown)-REGIONAL.  
 Gillette: George Amos Memorial Library (1980).  
 Laramie:  
     University of Wyoming, Coe Library (1907).  
     University of Wyoming Law Library (1978).  
 Powell: Northwest Community College Library (1967).  
 Riverton: Central Wyoming College Library (1969).  
 Rock Springs: Western Wyoming Community College Library (1969).  
 Sheridan: Sheridan College Library (1963).



## APPENDIX B. LIST OF DISTRICT OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

### ALABAMA

**Birmingham**—Gayle C. Shelton, Jr., Director, Suite 200-201, 908 South 20th Street, 35205, Area Code 205 Tel 254-1331, FTS 229-1331

### ALASKA

•• **Anchorage**—Director (Vacant), 701 C Street, P.O. Box 32, 99513, Area Code 907 Tel 271-5041, FTS Dial 8 399-0150, Ask for 271-5041

### ARIZONA

**Phoenix**—Donald W. Fry, Director, Suite 2950 Valley Bank Center, 201 North Central Avenue 85073, Area Code 602 Tel 261-3285, FTS 261-3285

### ARKANSAS

•• **Little Rock**—Director (Vacant), Suite 635, Savers Federal Building, 320 W. Capitol Avenue, 72201, Area Code 501 Tel 378-5794, FTS 740-5794

### CALIFORNIA

•• **Los Angeles**—Daniel J. Young, Director, Room 800, 11777 San Vicente Boulevard 90049, Area Code 213 Tel 209-6707, FTS 793-6707

• **San Diego**—110 West C Street, 92101, Area Code 714 Tel 293-5395

**San Francisco**—Betty D. Neuhart Director, Federal Building, Box 36013, 450 Golden Gate Avenue 94102, Area Code 415 Tel 556-5860, FTS 556-5868

### COLORADO

•• **Denver**—Donald L. Schilke, Director, Room 119, U.S. Customhouse, 721-19th Street, 80202, Area Code 303 Tel 837-3246, FTS 327-3246

### CONNECTICUT

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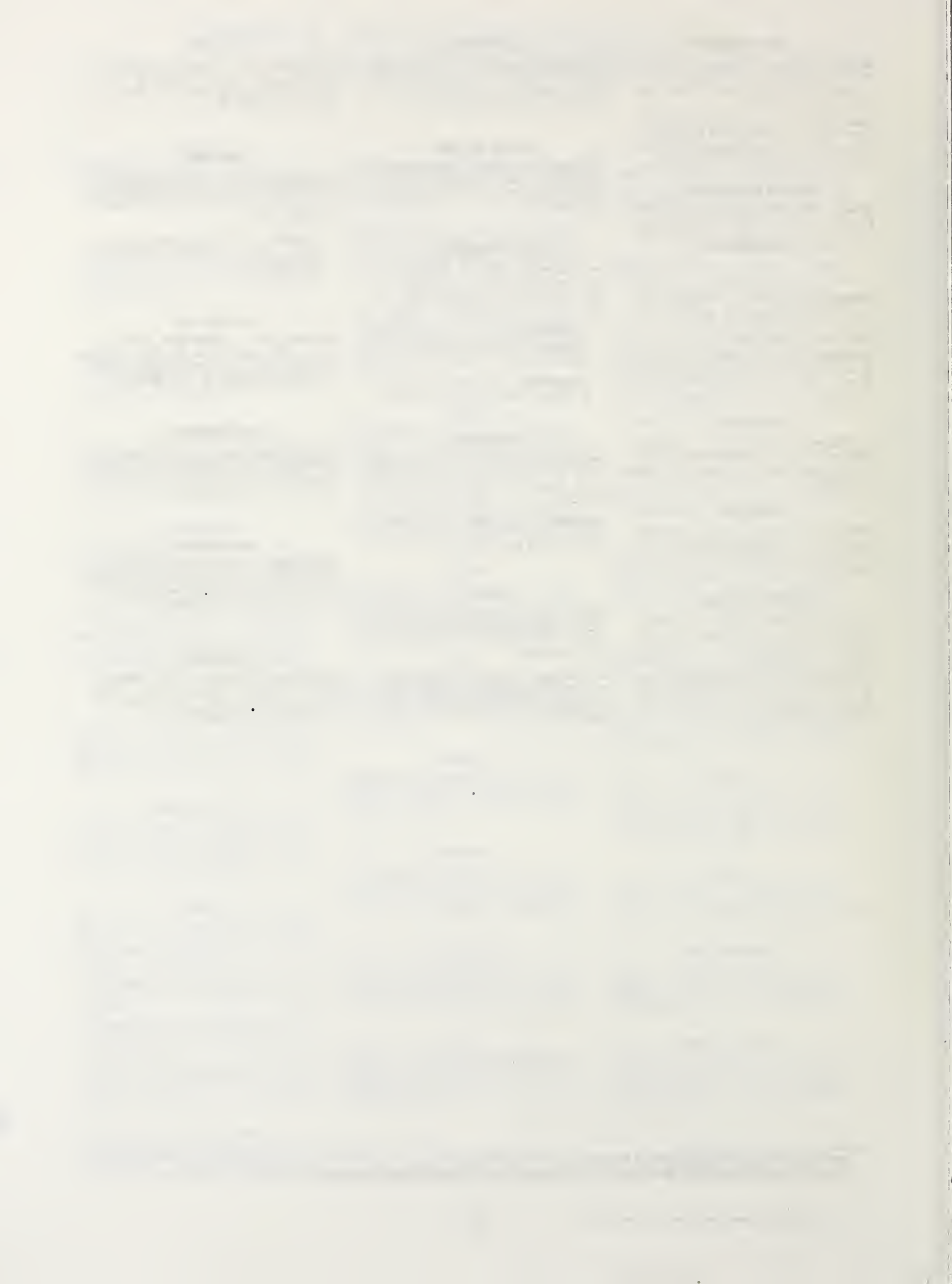
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10	Charlotte Adams	21
11	William Baker	33
12	Margaret Green	26
13	Richard King	31
14	Susan Lee	23
15	Daniel Hall	36
16	Elizabeth Scott	20
17	John Young	34
18	Mary King	29
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20	Anna Clark	25
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24	Margaret King	26
25	Richard Lee	31
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27	Daniel Adams	36
28	Elizabeth Baker	20
29	John Green	34
30	Mary King	29
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*Journal of Research*

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